Issued March 1941

Soil Survey

Ingham County Michigan

By
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Michigan Agricultural Experiment Station
and
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United States Department of Agriculture

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF PLANT INDUSTRY
In cooperation with the
Michigan Agricultural Experiment Station

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Series 1933, No. 36 Issued March 1941

SOIL SURVEY OF INGHAM COUNTY, MICHIGAN

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Area inspected by MARK BALDWIN, Inspector, District 1

United States Department of Agriculture in cooperation with the Michigan Agricultural Experiment Station

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INTRODUCTION

Ingham County is located in a part of Michigan that was settled approximately 100 years ago. The first settlers came to establish farm homes and not primarily to exploit timber or mineral resources. During this early period, ownership of the land was in small units, clearing of the land was slow, laborious, and costly, and farming necessarily was of a subsistence type. Farming became more commercialized as the population increased; industries, other than agriculture, became established; and transportation facilities and better markets were developed. Under the conditions of early settlement, and subsequently when the incentive for monetary profit was greater, the use of the land was largely exploitative. Probably, with a few exceptions, this is still true in the sense that the users of the land are drawing mainly on the natural fertility and are doing little long-time planning to preserve the productivity or to replace the plant nutrients taken by crops. Here, as elsewhere, the most efficient use of land on a long-time or social basis has been complicated by individualism, size of farms, and economic and social conditions, as well as by natural conditions.

In the early stages of settlement, little or no guidance in the selection of land was given by the Government to the settlers. Furthermore, the rectangular system of land surveying and consequent

[1] The Soil Survey Division was transferred to the Bureau of Plant Industry July 1, 1939.

allotment of land according to arbitrary units, contrary to natural boundaries, resulted eventually in waste of both human effort and the land itself. Perhaps in some places the less fertile and durable soils were deliberately selected for cultivation, because they were easier to clear and to till and offered more healthful sites for habitation. Much of the sandier and sloping land, which is now marginal in character, afforded good subsistence farms in the early days; in fact, the farms were even prosperous, until the fertility was reduced, or until the sloping land deteriorated because of soil erosion, or until competition from the smoother land containing heavier, more productive, and durable soils, made them less valuable.

FIGURE 1.—Sketch map showing location of Ingham County, Mich.

Some attempt has been made to adjust land use to the prevailing economic conditions and to the natural conditions of the landscape, but lags here and there in making adjustments and numerous instances of misuse and abuse of land, for which the occupant may or may not be responsible, may be pointed out. Neither ideal conservation nor complete efficiency in land use for individual profit is to be expected, but a wider knowledge of the several kinds of soil and their geographic distribution is conducive to better utilization of the land. The potentialities for agricultural production have not yet been fully realized, the virgin fertility and natural productivity are not yet generally exhausted, and approximately 20 percent of the rural area has never been cleared for agricultural use. Further adjustments in accordance with changing economic and social conditions are possible. Competition in the future, however, may allow profitable use of only the best land for the production of cultivated crops, leaving a large acreage for grass or pasture or for some nonagricultural use. But whether or not the trend is toward an increase or a decrease in acreage devoted to cultivated crops, a wider knowledge of the character of the soils should aid in developing plans for the best land use.

Although the soil survey does not provide a map of all the minute details of soil and surface features or a solution to all the problems of

soil management on individual farms, it does supply both the general and specific information about soil and surface features the agriculturist needs for working out his problems. It further furnishes a basis for comparison of the natural land resources of this county with other counties in the State, and, therefore, contributes to a larger knowledge of these resources.

COUNTY SURVEYED

Ingham County is in the south-central part of the Lower Peninsula of Michigan (fig. 1). It has an area of 553 square miles, or 353,920 acres.

The county is in the southern upland division of this part of the State. This physiographic feature is a broad glaciated plain, which rises from 200 to 600 feet above Lakes Michigan, Erie, and Huron and their bordering lake-bed plains, and from 200 to 400 feet above the lowland plain on the north, which extends across the central part of the State from Saginaw Bay to Lake Michigan. The relief as a whole is smooth or gently undulating, although some parts are choppy and comparatively hilly. The secondary topographic features are those common to the moraines, till plains, outwash plains, and old glacial drainage valleys of this section. They consist of rounded hills, comparatively deep basins, and a complexity of short slopes; patches of smooth or pitted sandy and gravelly plains; linear gravelly hogback ridges; small shallow pot holes and shallow swales and complementary low swells of upland; and widely distributed swamps and lakes of various sizes and shapes. As streams are not numerous, stream dissection is comparatively slight. The extreme difference in elevation between the highest and lowest points in the county is less than 300 feet, and local differences between the levels of swamps, lakes, or stream valleys and the adjacent higher land generally do not exceed 100 feet. Most of the slopes are short, smooth, and rounded, rather than angular. They are related to constructional features of glacial origin rather than to subsequent stream dissection or geological erosion.

At the time of settlement by white men, the county was entirely covered by forest, except for a small aggregate area of marshland and water, comprising together not more than 3 or 4 percent of the total area of the county. Present estimates indicate that about 15 percent remains in forest similar to the original cover, which consisted of various associations of hardwoods. The principal species were red oak, white oak, black oak, hickory, beech, sugar maple, ash, American linden or basswood, elm, red maple, silver maple, and swamp white oak. In places walnut, butternut, black cherry, sycamore, cottonwood, hackberry, and tuliptree, locally known as tulip poplar, grew, though not in such heavy stands. The principal trees in the wetter peat swamps were tamarack, aspen, red maple, elm, willow, and a few black spruce, and the shrubs, such as red-osier dogwood, winterberry, huckleberry, and chokeberry, were common associates. In the marshy land the characteristic growth was wire grass, a sedge (*Carex filiformis*), and bluejoint, together with a great variety of species of *Carex*, *Cyperus*, *Juncus*, and *Scirpus*. In bogs, leatherleaf, blueberry, and hypnum and sphagnum mosses were characteristic.

The population of the county, according to the 1930 Federal census, is 116,587, of which 85,361 is classed as urban and 31,226 as rural.

The population includes 8,383 foreign-born white persons, 1,474 Negroes, and 92 persons of other races; the rest are native whites. Lansing, the largest city, has a population of 78,397. Other cities and towns of considerable size are East Lansing, with a population of 4,389; Mason, 2,575; Williamston, 1,458; Leslie, 1,105; Stockbridge, 715; Webberville, 488; and Dansville, 315.

Manufacturing, based on the value of products and number of people engaged, is the principal industry. The total value of all agricultural crops, nursery products, and forest products cut on farms in 1929 was $3,382,161, and the estimated value of farm land and buildings was $23,393,307. East Lansing is the seat of Michigan State College and the Michigan Agricultural Experiment Station.

Transportation facilities are excellent. Three United States highways cross at Lansing: No. 16, which also passes through Webberville; No. 127, which approaches Lansing from the south through Leslie and Mason; and No. 27, which cuts across the extreme northwestern corner of the county. In addition, there are paved State highways and excellent county roads. Three railroads enter the county: the New York Central Railroad, the Grand Trunk Railway, and the Pere Marquette Railway.

Detroit and Chicago are the principal markets for the agricultural products. Detroit is about 75 miles distant from Lansing and is easily accessible by rail, bus, and private automobile.

CLIMATE

The climate of Ingham County is characterized by fairly cold winters and mild summers. The normal annual precipitation is 31.43 inches, including melted snow. The yearly snowfall averages 47.4 inches. Wind movement and evaporation are relatively low, and humidity is moderately high. This part of Michigan receives about 50 percent of the possible sunshine.

The mean annual temperature is 46.9° F. The mean winter temperature is 24.2° and that of summer 68.6°. The average length of the frost-free season, from May 3 to October 10, is 160 days, which is ample, at this latitude, for maturing the staple crops grown. Although frosts have been recorded as late as May 28 and as early as September 8, crops seldom are damaged seriously by such late and early frosts, except on muck land and in the bottoms of pothole basins.

The precipitation is fairly evenly distributed throughout the year and is sufficient for a high crop production. Although the rainfall shows considerable annual and seasonal variation and marked differences exist in the moisture-holding capacity of the soils receiving the same amount of precipitation, general crop failures due to a deficiency or an excess of water have never occurred. Snowfall may be depended on every winter to give fall-sown grain crops some protection, but a snow cover may not be continuous, and occasional damage due to the freezing of water on fields is to be expected. Hailstorms sometimes occur during the summer, but they seldom cause much damage to crops.

The prevailing winds are westerly. They rarely attain high velocity and are, therefore, seldom destructive to crops on the cultivated soils, except on the very dry muck soils and the loose incoherent sands in the more exposed situations.

The climate does not present any very marked differences throughout the county, as the differences in altitude are not great and there are no very large bodies of water. Purely local differences in susceptibility of crops to damage from frost are observed, and some slight differences may be observed in relation to fruit growing, the occurrence of frost depending on the situation, whether on hills or in depressions, and the direction of the slope of the land.

Weather data of value in relation to agriculture are presented in table 1, compiled from the records of the United States Weather Bureau station at Lansing.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Lansing (MSC), Ingham County, Mich.*

[Elevation, 856 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1930)	Total amount for the wettest year (1883)	Snow, average depth
	° *F.*	° *F.*	° *F.*	*Inches*	*Inches*	*Inches*	*Inches*
December	27.2	62	−24	2.07	0.91	1.28	10.0
January	22.4	63	−26	1.82	2.53	1.53	11.9
February	22.9	66	−25	1.90	1.41	4.50	11.4
Winter	24.2	66	−26	5.79	4.85	7.31	33.3
March	32.2	82	−12	2.35	1.47	.71	7.9
April	45.6	88	8	2.58	1.97	1.90	1.6
May	56.9	95	17	3.42	3.36	5.66	.2
Spring	44.9	95	−12	8.35	6.80	8.27	9.7
June	66.4	99	34	3.51	2.79	11.35	.0
July	70.9	102	37	3.10	.50	11.27	.0
August	68.5	102	32	2.82	.18	.18	.0
Summer	68.6	102	32	9.43	3.47	22.80	.0
September	61.4	99	21	2.91	1.42	2.34	.0
October	50.3	90	10	2.47	1.00	3.66	.6
November	37.5	74	0	2.48	.96	3.98	3.8
Fall	49.7	99	0	7.86	3.38	9.98	4.4
Year	46.9	102	−26	31.43	18.50	48.36	47.4

AGRICULTURE

The first permanent settlements made by white men in Ingham County began in the decade 1830–39. The pioneers came mainly from New York, Pennsylvania, and Ohio. As was true in most parts of the Middle West, the pioneer farmers, of necessity, followed a system of mixed agriculture and produced the crops required for home consumption to a much greater extent than was done later. In the earlier periods of settlement, cattle, furs, alkaline salts from wood ashes, and, later, lumber were sources of cash income.

The influx of settlers was steady, and the increase in the acreage of land placed under cultivation was rapid until about 1880, but in succeeding decades the increase was very slight. Wheat, corn, hay, and potatoes were staple crops in the early days. The production of wheat was greatest in 1899, and it has declined sharply since. The acreage in corn, oats, and hay increased until 1909, after which these acreages decreased, although only slightly. Rye and barley became fairly important crops in 1919 but now are not produced so exten-

sively. Dry beans have been grown extensively since 1909. Red clover, as a hay crop, has given way to alfalfa in late years. Livestock raising has been marked by a decrease in the number of beef cattle and an increase in the number of dairy cattle. As in other parts of Michigan, agriculture here has been influenced greatly by the marked industrial expansion and growth of cities in this section. The urban growth has been the cause of the abandonment of some farms, but, on the other hand, it has brought about the development of small part-time farms, the production on individual farms of a greater number of direct-income products, the development of specialized farming, and an increase in dairying.

The present-day agriculture is of three types: (1) General farming, including the growing of grain and hay for feeding dairy cattle or other livestock; (2) a less distinct type, which consists of general farming combined with the production of some special cash crop; and (3) the production of specialties, such as poultry, fruit, vegetables, and flowers, on small farms. General farming is neither highly intensive nor extensive, and most of the farms used for general farming range in size from 80 to 300 acres. The farmer depends on average results for his profit, and much the same methods are followed and the same crops grown year after year. The farmer still relies mainly on the inherent productiveness of the soil, although farming is passing from the purely exploitative stage to that in which measures are being taken to maintain productiveness or to increase yields, through liming, the use of commercial fertilizers, more careful selection of seeds, and intensive tillage methods.

Table 2 gives the acreage of the more important crops grown at intervals from 1879 to 1934, as reported by the Federal census.

TABLE 2.—*Acreage of the principal crops grown in Ingham County, Mich., in stated years*

Crop	1879	1889	1899 [1]	1909	1919	1929 [1]	1934 [1]
	Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
Corn for grain	22,969	26,750	32,711	33,812	28,682	7,938	14,044
Corn for other purposes					[2] 7,236	16,763	18,230
Oats for grain	11,245	23,364	21,562	29,991	29,635	22,158	24,387
Oats, cut and fed unthreshed						287	1,358
Wheat	49,257	37,248	56,846	7,925	13,548	19,421	18,197
Rye	97	2,565	910	8,634	22,678	1,356	2,013
Barley	748	3,259	816	3,064	8,902	5,260	2,212
Buckwheat	803	1,171	375	730	763	290	
Mixed grains						1,257	1,921
Dry edible beans			9,370	16,000	6,676	18,304	17,192
Soybeans					185	192	488
All hay	29,687	42,638	49,193	56,324	51,216	45,095	49,832
Timothy and clover				51,665	44,575	22,560	21,351
Clover alone			4,393	2,910	1,744	9,239	759
Alfalfa			5	65	1,061	10,744	19,755
Grains cut green			297	10	164	178	1,311
Legumes for hay					217	174	3,270
Other tame hay			42,174	185	1,148	487	[3] 3,386
Wild hay			2,324	1,489	2,307	1,713	
Potatoes	2,413	3,130	3,068	3,165	2,198	2,090	3,010
Sugar beets			100	877	790	443	1,800
	Trees	*Trees*	*Trees*	*Trees*	*Trees*	*Trees*	*Trees*
Apples		225,204	275,528	143,632	72,513	53,749	54,849
Peaches		6,598	32,041	16,352	4,426	3,970	12,499
	Vines	*Vines*	*Vines*	*Vines*	*Vines*	*Vines*	*Vines*
Grapes			10,929	4,604	6,365	10,579	16,190
	Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
Strawberries			110	79	70	87	131

[1] Number of trees and grapevines for 1900, 1930, and 1935.
[2] For forage only.
[3] Includes wild hay.

In addition to the crops listed in table 2, the 1930 census reports that, in 1929, 1,132 acres were devoted to vegetables grown for sale, 6,211 acres to clover for seed, and 140 acres to mint. In the same year, 1,455 acres were in sweetclover for pasture. The acreage of vegetables grown for sale increased to 1,850 acres in 1934, but no data were gathered for clover seed, mint, and sweetclover pasture. Cabbage, celery, asparagus, lettuce, onions, tomatoes, carrots, cantaloups, and sweet corn are the principal truck crops. The most important orchard fruit in number of trees is apples; peaches, pears, plums, and cherries are also grown. The principal small fruits are raspberries and strawberries. Grapes grow vigorously but are susceptible to damage from spring frosts.

The number and value of livestock are given in table 3.

TABLE 3.—*Number and value of livestock in Ingham County, Mich., in stated years*

Livestock	1900		1910		1920		1930		1935 [1]
	Number	*Value*	*Number*	*Value*	*Number*	*Value*	*Number*	*Value*	*Number*
Cattle	29,788		28,538	$845,764	29,301	$2,199,931	25,090	$1,612,394	26,276
Horses	13,011		12,451	1,399,039	11,731	981,226	6,918	726,473	6,926
Mules	33	$1,639,858	83	10,070	65	7,075	106	11,590	70
Sheep	105,961		107,453	407,136	53,551	572,170	72,202	559,244	59,492
Swine	24,991		30,132	241,075	28,199	541,852	10,735	135,395	10,565
Chickens	[2] 173,294	54,308	[2] 195,347	[2] 110,657	[2] 213,582	235,359	174,446	163,979	190,267
Bees (hives)	1,850	5,909	2,425	8,590	1,529	7,301	1,342	7,247	

[1] Value not reported.
[2] All poultry.

The values of the principal agricultural and livestock products of the county in 1929 were as follows:

Cereals	$1,140,450
Other grains and seeds	612,376
Hay and forage	925,625
Vegetables, including all potatoes	290,251
Fruits and nuts	105,872
All other field crops	48,488
Farm garden vegetables, excluding all potatoes	37,078
Nursery and greenhouse products	69,497
Forest products cut on farms	152,524
Dairy products sold	1,568,517
Poultry raised	318,106
Chicken eggs sold	283,332
Wool shorn	159,299
Honey produced	9,504

As may be seen from the foregoing tabulation, dairy products are an important source of cash income. The most important dairy product is whole milk. In 1929, 13,055 cows were milked and produced 8,299,095 gallons of milk, of which 5,971,558 gallons, valued at $1,373,458, was sold as whole milk. In the same year 316,320 pounds of butterfat, valued at $151,834, and 82,107 pounds of butter, valued at $39,411, were sold. The production of milk increased in 1934, when 15,353 cows were milked and produced 8,967,479 gallons of milk.

Poultry products also provide a good income to the farmers. Of the 308,347 chickens raised in 1929, valued at $299,097, 161,339 were sold alive or dressed. Other poultry raised included 2,034 turkeys, 6,428 ducks, and 2,797 geese, valued at $6,204, $7,071, and $5,734, respectively. Of the 1,297,503 dozens of chicken eggs produced in 1929,

913,974 dozens, valued at $283,332, were sold. In 1934, 266,347 chickens were raised and 1,327,600 dozens of eggs produced.

Wool is another source of farm income. In 1929, 55,746 sheep and lambs were shorn, producing 468,526 pounds of wool, valued at $159,299. Fewer sheep and lambs, 50,901, were shorn in 1934, and the production of wool decreased correspondingly to 428,136 pounds.

An expenditure of $400,377 for feed was reported in 1929 by 1,744 farms, or $229.57 a farm reporting. An almost equal expenditure, $391,344, was made for labor on 1,324 farms, or $295.58 a farm reporting.

Fertilizers are coming into general use. More than one-half of the farmers reported the purchase of commercial fertilizers in 1929 at a total cost of $124,585, or an average of $82.56 for each of the 1,509 farms reporting. The tendency is toward an increase in their use for all crops and the application of higher-grade mixtures, but, in general farming, barnyard manure still is largely depended on to maintain productiveness. Potash alone or mixtures of high potash content are in common use for truck crops on muck land, and, in addition, other fertilizers or correctives, such as sulfur, copper sulfate, and manganese, are used to a small extent. Lime is becoming more generally used, especially where it is desired to grow alfalfa. The forms of lime commonly used are ground limestone, refuse lime from the beet-sugar factory at Lansing, and marl of local origin.

In 1935 there were 3,218 farms in the county with an average size of 97.5 acres, of which 66.5 acres were classed as land available for crops. Since 1900 the trend has been toward a decrease in number of farms, an increase in their average size, and a decrease in the total acreage of farm land and improved farm land. The census reports the average value of land and buildings a farm as $7,900 in 1930 and $5,699 in 1935. The average acre value of land and buildings was reported as $76.89 in 1930 and $58.12 in 1935.

In 1935, owners operated 77.6 percent of the farms, tenants 21.7 percent, and managers 0.7 percent. Tenancy has increased only slightly since 1900. The 1935 census reported the farm population as 12,827 persons.

SOIL-SURVEY METHODS AND DEFINITIONS

Soil surveying consists of the examination, classification, and mapping of soils in the field.

The soils are examined systematically in many locations. Test pits are dug, borings are made, and exposures, such as those in road or railroad cuts, are studied. Each excavation exposes a series of distinct soil layers, or horizons, called, collectively, the soil profile. Each horizon of the soil, as well as the parent material beneath the soil, is studied in detail; and the color, structure, porosity, consistence, texture, and content of organic matter, roots, gravel, and stone are noted. The reaction of the soil [2] and its content of lime and salts are determined by simple tests.[3] Drainage, both internal and external, and other external features, such as relief, or lay of the land, are

[2] The reaction of the soil is its degree of acidity or alkalinity, expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality, higher values indicate alkalinity, and lower values indicate acidity.

[3] The total content of readily soluble salts is determined by the use of the electrolytic bridge. Phenolphthalein solution is used to detect a strong alkaline reaction.

taken into consideration, and the interrelation of soils and vegetation is studied.

The soils are classified according to their characteristics, both internal and external, special emphasis being given to those features influencing the adaptation of the land for the growing of crop plants, grasses, and trees. On the basis of these characteristics soils are grouped into mapping units. The three principal ones are (1) series, (2) type, and (3) phase.

The most important group is the series, which includes soils having the same genetic horizons, similar in their important characteristics and arrangement in the soil profile, and developed from a particular type of parent material. Thus, the series includes soils having essentially the same color, structure, and other important internal characteristics and the same natural drainage conditions and range in relief. The texture of the upper part of the soil, including that commonly plowed, may vary within a series. The soil series are given names of places or geographic features near which they were first found. Thus, Miami, Hillsdale, and Conover are names of important soil series in this county.

Within a soil series are one or more soil types, defined according to the texture of the upper part of the soil. Thus, the class name of the soil texture, such as sand, loamy sand, sandy loam, loam, silt loam, clay loam, silty clay loam, and clay, is added to the series name to give the complete name of the soil type. For example, Fox sandy loam and Fox loam are soil types within the Fox series. Except for the texture of the surface soil, these soil types have approximately the same internal and external characteristics. The soil type is the principal unit of mapping, and because of its specific character it is usually the soil unit to which agronomic data are definitely related.

A phase of a soil type is a variation within the type, which differs from the type in some minor soil characteristic that may have practical significance. Differences in relief, stoniness, and the degree of accelerated erosion frequently are shown as phases. For example, within the normal range of relief for a soil type, there may be areas that are adapted to the use of machinery and the growth of cultivated crops and others that are not. Even though there may be no important difference in the soil itself or in its capability for the growth of native vegetation throughout the range in relief, there may be important differences in respect to the growth of cultivated crops. In such an instance, the more sloping parts of the soil type may be segregated on the map as a sloping or a hilly phase. Similarly, soils having differences in stoniness may be mapped as phases, even though these differences are not reflected in the character of the soil or in the growth of native plants.

The soil surveyor makes a map of the county or area, showing the location of each of the soil types, phases, and miscellaneous land types, if any, in relation to roads, houses, streams, lakes, section and township lines, and other local cultural and natural features of the landscape.

SOILS AND CROPS

In the following pages the soils are described. The soil types, as shown on the map, are regarded as combinations of the elements of

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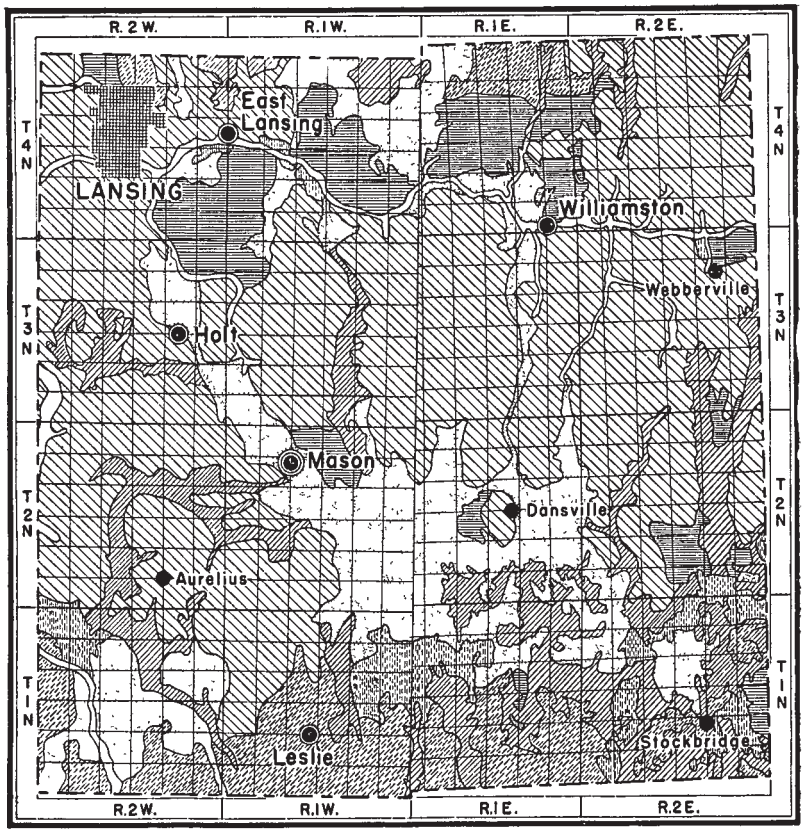
internal soil characteristics and such external features as topography and vegetation, or specific associations of different kinds of soil and associations of topographic features. The description of the land area of soil types, therefore, may be as significant as the technical description of the internal chemical and physical characteristics of the soil, as a basis for land use. Likewise, a grouping of soils on the basis of some single feature, which is directly related to the practical management of land, such as drainage, texture, or productivity, may be important for practical purposes. The purely pedologic descriptions and the scientific classification are essential for the accurate identification and mapping of kinds of soil, and they provide basic knowledge for the better understanding of practical problems in land management for making the inventory of soil and land resources. The discussion of the origin of the soils and their technical classification, however, is reserved for a subsequent part of this report.

The broader natural divisions of the land in the county are shown on the sketch map (fig. 2), and smaller divisions designated as soil types are shown on the accompanying soil map. Divisions carried still further to the point of recognizing separate phases of soils and separate minor features of the relief may be useful in management and planning for individual farms, but the delineation of such detail is impracticable on maps for such large areas as a county. These variations can be recognized on the ground by inspection, with the soil map as a guide and with a knowledge of the soil types as herein described.

The broader natural divisions of land in the county (fig. 2) consist of: (1) Nearly level clayey plains; (2) undulating sandy clayey plains; (3) hilly sandy clay land, swamp basins, and valleys; (4) hilly sandy land, pot holes, lakes, dry sandy plains, swampy basins, and valleys; (5) level sandy and gravelly plains; (6) swampy plains and valleys, low islands, and hillocks of sand; (7) river valley land—stream, swampy, and dry bottom land, slopes, and bluffs.

Other features that have a marked influence on the value and use of land, both locally and in general, are the shallow circular or oval depressions, ranging from ¼ to 5 acres in size, scattered throughout the plain areas of both sandy and clayey glacial drift; deep basins, or pot holes, containing either lakes or swamps in the hillier land; the eskers, which are narrow, steeply sloping, winding gravelly and sandy ridges; old glacial drainage valleys; shallow swales; and a complexity of slope types inherited from the action of the ice lobe that covered this part of the State. The depressions may be dry, or they may be ponds occupied by cattails, sedges, and other aquatic plants, or by shrubs and trees, such as buttonbush, willow, ash, aspen, elm, and red maple. The slopes do not have definite direction conforming to valleys, such as those formed by stream dissection, but rather conform to basin depressions, which, in many places, are circular or elliptical in outline; slopes may be compound rather than simple, and surfaces may be billowy and choppy, characterized by a succession of gentle slopes, low ridges, and hillocks, and in other places an association of gentle and short steep slopes.

The soils of Ingham County differ widely in texture, structure, chemical composition, fertility, and moisture—natural factors that



LEGEND

Nearly level clayey plains; low relief; gentle slopes; Miami, Conover, Brookston soil association.

Undulating sandy clayey plains; low relief; gentle slopes; high proportion swampland; Hillsdale, Miami, Conover soil association.

Hilly sandy clay land, swamp basins and valleys; relief 50 to 100 feet; high proportion of moderately steep slopes; Hillsdale, Miami, Bellefontaine soil association.

Hilly sandy land; pot holes; lakes, dry sandy plains, swampy basins and valleys; relief 50 to 150 feet; complexity of short and steep slopes greater in area than level land; Bellefontaine, Hillsdale, Coloma, Fox soil association.

Level sandy and gravelly plains; low relief; shallow wet and dry pits; swamp basins; Fox, Plainfield, Oshtemo, Berrien soil association.

Swampy plains and valleys; low islands and hillocks of sand; gravelly and clayey soils included.

River valley land, stream, swampy, and dry bottom land; slopes and bluffs of enclosing high land

FIGURE 2.—Sketch map showing broad natural land divisions.

bear a relation to plant growth and consequently to agricultural use. They also exhibit a lack of uniformity on most individual farms, as diverse soils are intimately associated in small bodies, a condition inherent from glaciation and common to the State as a whole.

The plow layer ranges from loose incoherent sand to moderately heavy silt loam and clay loam, although most of the soils are loams and sandy loams. The sands and loamy sands comprise less than 10 percent of the total area of the county and soils that have a clay or clay loam mixture in the plow soil, less than 5 percent of the total acreage. The clays and clay loams are included on the map with the loams. Probably 65 percent of the land is loamy or free working under all conditions, about 10 percent is moderately heavy, and about 5 percent is refractory or difficult to manage because of a high content of clay, extreme stoniness, susceptibility to blowing, or other unfavorable tilth conditions. About 15 percent consists of muck and peat, which have their own peculiar tilth characteristics.

It is estimated that 30 percent of the soil is comparatively low [4] in organic matter in the plow layer, containing less than 2 percent by weight; about 45 percent is intermediate, or contains from 2 to 4 percent by weight; and about 25 percent, including muck and peat, has a high organic-matter content. The humous layer in virgin well-drained soils does not exceed 3 inches in thickness, and consequently, in the cultivated soil, very little coloring from organic matters appears below a depth of 6 or 7 inches. The soils are deeply penetrable, however, as the parent soil material is unconsolidated glacial drift to a depth of several feet.

About 90 percent of the soils are acid in reaction in the surface horizons, either in the upper humus-containing layer or in the layers just beneath, and therefore, in the plow soil; but practically all of the soils, except some peats, contain sufficient calcium and magnesium carbonates, or other bases, at a depth of less than 40 inches, to give an alkaline reaction. Under natural conditions, about 10 percent of the soils are nearly neutral or alkaline, in both the surface and subsurface layers. The organic soils, comprising about 15 percent of the area of the county, are, for the most part, nearly neutral or moderately acid, and only a small proportion is extremely acid peat characterized by a pH value of less than 4.

In the greater part of the county natural drainage is fairly good, as the water table is not high and the slope is sufficient to provide free run-off. It is estimated that 25 percent of the soils are characterized either by a high water table or by a permanently swampy condition and are, therefore, unsuitable for agricultural use other than pasture unless they are ditched or tiled.

The fertility and productivity of most of the soils, according to standards for the southern part of Michigan, are medium. Analyses of the predominant types of mineral soil represented here do not show any evidence of abnormally high or, on the other hand, of unusually low contents of the mineral plant nutrients ordinarily determined in analysis. Probably 10 percent of the soils, including

[4] These are local values and therefore should not be regarded as generally accepted standards for other parts of the United States.

the sands and loamy sands, are poor because of a combination of low content of readily available plant nutrients and deficiency of moisture. A large proportion of the land, about 15 percent, comprising the mucks and peats, is poor in mineral elements, particularly potassium, although moisture may be excessive.

The type of soil, including surface features and geographic location, has considerable influence on the yield and distribution of certain crops, in effecting variations in the common type of general farming and in the distribution of woodland and unused land.

General farming, including dairying or the raising and feeding of livestock, is carried on most extensively on the soils of the Miami, Hillsdale, and Conover series. Rye and buckwheat replace wheat and barley to some extent on the most sandy and acid soils, such as the Coloma, Plainfield, and Berrien, and the sandier areas of Bellefontaine sandy loam. Special crops, such as melons, strawberries, raspberries, and tomatoes, are grown on light sandy soils, such as Plainfield loamy sand, Fox sandy loam, Berrien loamy sand, and Coloma loamy sand, although in general the location of small farms for special crops is determined largely by proximity to Lansing. Celery, cabbage, onions, and mint are grown extensively on muck.

Farm land that has been abandoned consists principally of Plainfield loamy sand, Coloma loamy sand, and the more rolling or hilly areas of Bellefontaine sandy loam and Hillsdale sandy loam. The organic soils (muck and peat) constitute the greatest proportion of the unused virgin land. The greatest acreage of woodland and pasture is on muck, the poorly drained mineral soils, such as members of the Brookston and Brady series, the alluvial soils, and the other soils naturally least suited to cultivated crops because of unfavorable surface features, low fertility, and unfavorable location.

In interpreting or drawing conclusions from the soil map, it should be understood that soil types in few places are sharply separated but rather grade into each other, so that precise lines of demarcation are not to be expected. Areas of other soils and minor variations may be included on the map with each soil type shown, so that each color or pattern on the soil map must be understood to represent the dominant or characteristic kind of soil and not always a single soil strictly uniform in every respect.

Perhaps the most useful grouping of the soils in this county, in relation to management, particularly tillage, is on the bases of texture of parent materials and natural drainage, or water content. The individual soil types may be grouped as follows: (1) Well-drained clayey soils, (2) imperfectly and poorly drained clayey soils, (3) well-drained loamy and sandy soils, (4) well-drained very sandy soils, (5) poorly drained sandy soils, (6) alluvial soils, and (7) organic soils.

In the following pages the soils are described in relation to their agricultural adaptations and use; their distribution is shown on the accompanying soil map; and their acreage and proportionate extent are given in table 4.

TABLE 4.—*Acreage and proportionate extent of the soils mapped in Ingham County, Mich.*

Soil type	Acres	Per-cent	Soil type	Acres	Per-cent
Miami loam	44,672	12.6	Berrien loamy sand	3,072	0.9
Conover loam	75,776	21.4	Granby sandy loam	3,904	1.1
Brookston loam	24,832	7.0	Brady sandy loam	24,896	7.0
Washtenaw loam	2,496	.7	Maumee loam	2,368	.7
Wallkill loam	3,328	1.0	Griffin loam	5,056	1.4
Hillsdale sandy loam	58,752	16.6	Genesee fine sandy loam	2,176	.6
Bellefontaine sandy loam	8,768	2.5	Carlisle muck	34,496	9.7
Bellefontaine loamy sand	6,400	1.8	Houghton muck	1,408	.4
Fox sandy loam	16,256	4.6	Rifle peat	14,592	4.1
Fox loam	1,472	.4	Greenwood peat	640	.2
Coloma loamy sand	6,080	1.7	Kerston muck	3,008	.9
Ottawa loamy fine sand	768	.2			
Plainfield loamy sand	1,664	.5	Total	353,920	
Oshtemo loamy sand	7,040	2.0			

WELL-DRAINED CLAYEY SOILS

Clayey soils are so designated because of the character of the material beneath the plow layer, as the surface layer of most of the soils is silt loam or loam and in only a few instances is it clay or clay loam, according to the textural classification followed in soil classification. For soils in this section, this designation usually implies high moisture-holding capacity, fair to high natural fertility and productivity, and the need for greater power for tillage operations than is necessary for sandy soils. The well-drained clayey soils are classified as belonging to the Miami series, but many of the areas are farmed in conjunction with the Hillsdale, Conover, and Brookston soils, described under different groupings. The well-drained clayey soils, which in this county are represented by one soil type—Miami loam—comprise about 12.6 percent of the total area of the county.

Miami loam.—The plow soil of Miami loam in a dry condition consists of grayish-brown mellow fine-granular loam. Below this is pale-yellow or gray leached material, which is more gritty than that of the surface layer. At a depth ranging from 8 to 15 inches, this grades into brown compact gritty coarsely granular clay loam, which continues to a depth ranging from 36 to 40 inches. The substratum is comparatively hard gray or pale-yellow clayey calcareous glacial till, and it continues to a depth of several feet.

The surface, or plow, soil contains a medium supply of organic matter, and the fertility is considered medium to high, according to local standards. The subsoil, although sticky when wet and hard when dry, is sufficiently granular and jointed to allow root penetration. The average content of moisture in the clay is comparatively high but rarely is excessive, and it remains fairly uniform. Most of this soil is slightly to strongly acid, in both the virgin and the cultivated condition, to a depth ranging from about 24 to 36 inches. Below a depth of 36 inches considerable calcium carbonate (lime) is present in most places, and this gives the material an alkaline reaction.

Areas of Miami loam, as shown on the soil map, are not entirely uniform, and the description given above represents only the dominant or characteristic soil condition. The typical soil grades into sandy loam over more gritty friable sandy clay, on the one hand, and into silt loam over more plastic and less penetrable clay, on the other.

Small patches of associated soils, too small for separate mapping, are included. These are principally dark-colored moister and wet soils, in swales and depressions occupying an acre or two, which otherwise would be mapped as Washtenaw, Wallkill, Brookston, and Conover soils. Small spots of dry sandy soil also are included. On many steep slopes and crests of knolls, spots of yellow or reddish-brown cloddy subsoil materials are exposed as a result of accelerated erosion and loss of organic matter. Few farms of more than 40 acres are composed entirely of the typical Miami soil, so that as farm land it must be evaluated according to its associated soils and the proportion of the individual farm that it occupies.

Areas of Miami loam range from smooth and nearly level to rolling or even moderately choppy, but they are generally suitable for large-scale farming, involving the use of tractors and other heavy machinery. Serious sheet erosion, although not very apparent, is taking place even on gentle slopes, where the soil has been poorly managed, and on the steepest slopes some gullying has occurred, although this is not general. All the land originally was forested with a heavy growth of hardwoods, but at present probably 90 percent is cleared.

Under cultivation, Miami loam is a fairly productive and durable soil and is well adapted to general and subsistence farming. Hay (timothy and red clover), corn, wheat, and oats are the principal crops, in addition to alfalfa, navy beans, sugar beets, barley, cabbage, and potatoes. Orchard fruits, such as apples, pears, plums, peaches, and cherries, yield fairly well, but, with the exception of apples, probably not sufficiently well for commercial orchards. Most farmers utilizing this soil either carry on dairying or feed sheep and cattle for the market. Representative acre yields on the better farms comprised largely of this soil are as follows: Corn, 40 to 50 bushels; timothy and clover hay, 1½ tons; wheat, 25 to 30 bushels; and oats, 35 to 40 bushels. Crop rotation and barnyard manure are depended on chiefly to maintain productiveness, although the soil responds well to applications of commercial fertilizers. Both superphosphate (acid phosphate) alone and complete fertilizers generally give increased yields of wheat, beans, sugar beets, and such special crops as cabbage. Liming generally is beneficial for alfalfa and red clover, but it does not seem to be so essential, especially where the land has been well manured, as on the better drained sandier soils. Increase or maintenance of organic matter is perhaps most essential for maintaining permanent productivity.

This soil offers no especial difficulties in tillage if it is managed with ordinary care. Plowing may be done either in the fall or in the spring, but during wet springs some difficulty is experienced in obtaining a good seedbed. The associated swales and depressions of darker colored soil require tile drainage for best results.

IMPERFECTLY AND POORLY DRAINED CLAYEY SOILS

Imperfectly and poorly drained clayey soils comprise 30.1 percent of the total area of the county. These soils originally supported a dense forest consisting mainly of elm, ash, hickory, swamp white oak, basswood, and red maple, and because of difficulty of clearing

and drainage they were utilized for crops to only a small extent in the early days. At present, although not yet completely cleared and drained, they constitute perhaps the most durable and valuable soils for general farming, since, because of their poor drainage, they were not so leached under natural conditions as the well-drained soils. These soils are dark. The group includes two extensive soil types, Conover loam and Brookston loam, and two inextensive types, Washtenaw loam and Wallkill loam.

Conover loam.—Conover loam is a moderately heavy soil that has developed under drainage or moisture conditions intermediate between those of the driest clayey land represented by the Miami and Hillsdale soils and those of the wettest clayey land represented by Brookston loam.

In the virgin condition, typical Conover loam consists of dark grayish-brown mellow loam or silt loam to a depth of 4 or 6 inches. This is underlain by pale-yellow or gray friable gritty loam, which is more or less mottled in the lower part and which, at a depth ranging 10 to 15 inches, grades into moderately compact but penetrable clay of coarsely granular or nutlike structure, showing a mixture of gray, yellow, and brown colors. The substratum generally consists of a clay or clay loam calcareous glacial drift to a depth of several feet.

The soil is moderately well supplied with humus, is retentive of moisture, is nearly neutral or only slightly acid in reaction, and is well supplied with mineral plant nutrients. Where efficient tile drainage is provided, Conover loam is easily tilled and is one of the better soils for general farming, including the growing of small grains, corn, hay, alfalfa, beans, and sugar beets. Truck crops, such as cabbage, asparagus, and tomatoes, do well, but fruit and potatoes are not so well adapted. Where cleared of trees, this soil constitutes first-class pasture land, whether drained or undrained.

The land is very gently sloping or nearly level and occupies plains, basinlike valleys, and shallow swales. The larger plainlike bodies contain shallow pitlike depressions, a few feet in depth and ranging from ½ to 3 acres in size, which originally were intermittent or permanent ponds.

There are a number of inclusions of other soils on the soil map. Some of these small areas may be regarded merely as a darker phase of Miami loam, and others consist of small spots of Brookston loam. Textural variations in the plow soil range from heavy silt loam to sandy loam, and in a few places the surface is strewn with cobblestones and boulders. A few small included bodies have an ash-gray gritty layer over very compact clay. These lighter-colored wet soils are inferior in productiveness to the typically darker soil.

Brookston loam.—Brookston loam is developed on heavier materials of the flat basin lands, valleys, and depressions, which now are or originally were wet and swampy.

In a representative area, Brookston loam has a very dark gray or nearly black loam surface layer, which is rich in organic matter and ranges from 6 to 10 inches in thickness. It grades into a layer of gray or yellowish-gray more coherent and clayey material, from 4 to 8 inches thick, beneath which is steel-gray or bluish-gray more plastic or sticky clay, slightly mottled with yellow and rust brown.

The substratum consists of massive clayey glacial till containing more or less lime.

Variations in texture include areas of mucky soils and spots where considerable sand and gravel are mixed with the underlying clay. In places it has not been possible to make sharp distinctions between this soil and the Brady and Conover soils. Some of the soil in the smaller and narrower depressions associated with Miami loam contain considerable wash from the adjacent slopes, and some of the soils in valleys occupied by streams may be developed from alluvium in part.

Most of the soil indicated on the map as Brookston loam is relatively high in natural fertility. The content of organic matter is comparatively high and fairly durable under cultivation. The reaction is nearly neutral or even alkaline at the surface and alkaline or calcareous at a slight depth. In places the subsurface clay is hard and resistant when dry, but under natural conditions it is penetrable, and the depth to which roots can penetrate is limited by an excess of water and lack of aeration rather than by resistant soil material.

Brookston loam occupies many small separate bodies and, therefore, has less agricultural value for general farming than in other parts of the State, where it occurs as large uniform bodies. A large part of this land is still wooded.

The greater part of this soil is utilized for pasture and woodland, but where it is properly drained, excellent yields of corn, hay, oats, sugar beets, beans, truck crops, and alfalfa are obtained. Liming is not essential, and commercial fertilizers are not so necessary as on some other soils but may be profitably used. Drainage constitutes the main problem in the use of the land for cultivated crops, and where this is efficient, no special difficulties in tillage are experienced. The surface generally is free of stones except for an occasional large boulder.

Washtenaw loam.—Washtenaw loam occupies depressions in which the soil material has been washed from adjacent slopes and deposited over dark-colored soils. For the most part, the soil so accumulated represents the finer soil particles—clay, silt, and very fine sand—and contains a high proportion of humus. The thickness of the accumulated soil ranges from about 1 foot to 6 feet, beneath which an old or buried soil may be present. Some of this soil occupies small basins without outlets, and some of it is deposited in narrow drainage depressions. The bodies are very numerous, especially so in the hilly or more rolling parts of the county, in association with areas of the Miami, Hillsdale, and Bellefontaine soils, but they are so small that it is not practicable to show them all separately on the soil map.

In evaluating this soil as agricultural land, the chief depreciating factors are the small size of the separate bodies, inadequate drainage for some cultivated crops, and the fact that time of plowing and maturity of crops are not the same as on the adjacent land. Most of this soil is highly fertile, so much so that small grains frequently lodge. Lime is not needed for leguminous crops, and in general commercial fertilizers are not required. If they are used, smaller quantities are necessary than on the adjacent higher land.

Locally, small deltas of raw subsoil sand, gravel, and clay recently have been washed in from gullies, and in places peat or muck is present at slight depths. Such areas have the least value for cultivated crops. It is not practicable to indicate fine textural distinctions on the map because of the small size of the areas. The texture ranges from heavy silt loam to loamy sand, but most of the soil has a loam texture and is fairly uniform throughout.

Wallkill loam.—Wallkill loam does not represent a uniform soil type, but rather a condition, in which mineral soil material has been washed over peat or muck. It occurs in small basins or pot holes, in narrow strips at the bases of slopes, and as deltas on the edges of peat or muck swamps. The soil in the bottoms of many of the cattail and buttonbush ponds also is included under this classification.

In general, the soil is fine textured, dark, and fertile. It ranges in thickness from a few inches to 3 feet and ranges in texture from the gray jellylike mud of pond bottoms to sand.

The areas are so small and so numerous that it is not practicable to show them all on the soil map or to distinguish them in all places from Washtenaw loam.

This soil is generally productive where cropping is practicable and is especially suitable for truck crops and small garden plots. Much of it remains as wasteland because of the small size of the separate bodies, or because artificial drainage is impracticable. The cattail and buttonbush ponds depreciate the value of the land for general farming purposes but have some value as cover and sources of food for wildlife.

WELL-DRAINED LOAMY AND SANDY SOILS

The well-drained loamy and sandy soils are intermediate in texture between the very sandy soils, which are loosely coherent, and the silt loams and loams, which are comparatively heavy. Where clay underlies these sandy materials, it is generally sandier, more friable, and more penetrable than that under the clayey soils. Soils of this group are light-colored, are adapted to a greater diversity of crops, have fair natural fertility, and respond readily to applications of manure and commercial fertilizer. Although easier to till, they are less durable than the clayey soils and are somewhat more susceptible to destructive water erosion on slopes than either the very sandy or the clayey soils. The soils of this group comprise 25.9 percent of the total area of the county and are important in the agriculture.

Hillsdale sandy loam.—Hillsdale sandy loam, the most extensive member of this group, covers a considerable part of the rolling or moderately hilly well-drained land in the southern part of the county in the vicinity of Leslie, east of Lansing, and north of Williamston. Smaller bodies of both level and rolling land are scattered throughout the county.

A representative area of this soil consists of a plow layer of grayish-brown sandy loam or light loam, underlain by a 10- to 20-inch layer of pale-yellow friable sandy loam, which grades into a layer of yellow or yellowish-brown sandy fine-granular friable clay loam ranging from 18 to 24 inches in thickness. The substratum consists either of pervious sandy clay, which is moderately stony and gravelly in places, or of separate layers and pockets of sand, clay, and gravel.

The content of humus is not high, in either the virgin or the cultivated soil, but it is sufficient to impart a light-brown color. Although the subsurface layer contains sufficient fine material to make it moderately retentive of moisture, it is permeable and penetrable to a depth of several feet. In most places the reaction is medium or strongly acid from the surface to a depth ranging from 36 to 48 inches. The material below this depth gives an alkaline reaction but either contains more sandstone fragments and less limestone or contains less calcareous clay than the associated Miami and Bellefontaine soils.

Hillsdale sandy loam has the common textural variations of practically all of the soils in the county. The texture is sandier and the underlying material more pervious in places where this soil grades into the Coloma and Bellefontaine soils, and the content of clay is higher where it grades into Miami loam. Clay spots appear on some eroded slopes. In many places the surface soil is fine sandy loam; and small spots, in which the soil consists of a covering of sand or sandy loam over clay, as heavy as that underlying Miami loam, are also included with the Hillsdale soil. The distinction between the Hillsdale soil and the less gravelly areas of the Bellefontaine soils is not sharp, and this distinction probably is of small practical importance, as the smoother and less gravelly areas of both soils have similar agricultural value.

Areas of Hillsdale sandy loam are gently rolling or only moderately hilly. The gradient of most of the slopes is less than 10 percent, although in some areas it ranges from 15 to 25 percent. Practically all of the land is arable, but differences in slope and degree of stoniness are sufficient to effect appreciable differences in agricultural value and use of the land on individual farms. Natural drainage is everywhere sufficient for agricultural purposes on the typical Hillsdale soil, but on most farms the soil includes small basinlike depressions, cattail ponds, and swales, containing wet or dark-colored soils.

Oaks were dominant in the original forest growth, but other species, such as sugar maple, beech, hickory, black cherry, elm, and basswood, also were present.

General farming, including dairying or livestock feeding, is carried on with fair success on the smoother land. Special crops, such as potatoes, cabbage, cucumbers, melons, and small fruits, are grown, and many situations are favorable for orchard fruits, particularly apples.

Where the land is manured and properly handled, the productivity of the smoother areas is but little inferior to that of the Miami and Conover loams. Experience indicates that acre applications of 200 to 300 pounds of complete fertilizer may be profitable for grain, and larger applications are used to advantage for special crops. Liming may, in general, be beneficial, especially for alfalfa and red clover.

This soil does not become cloddy and is easily maintained in good tilth. Here and there are stones so large or so abundant as to hinder cultivation. Erosion is serious even on gentle slopes, unless precautions are taken to prevent it, and rills and gullies are common on cultivated slopes of 10 percent or steeper gradient.

Bellefontaine sandy loam.—The plow soil of Bellefontaine sandy loam, to a depth of 6 or 7 inches, is grayish-brown friable or loosely coherent sandy loam or fine sandy loam. This is underlain, to a depth ranging from 10 to 30 inches, by pale-yellow sandy loam. Beneath this the soil consists of reddish-brown sandy or coarse and gravelly material but contains sufficient clay to render the mass coherent and even slightly compact. This layer is undulating and patchy and ranges from a few inches to 3 feet in thickness. The substratum, or parent drift material, is a mixed mass of sand, gravel, boulders, and, here and there, pockets and layers of clay.

The proportion of organic matter contained in the virgin soil is only small to medium but is sufficient to impart a light-brown tint to the cultivated soil. The organic matter, or humus, is not so durable under cultivation as in the heavier soils. The surface soil is loose and pervious, but the underlying layer contains enough clay and is sufficiently compact to check the free downward movement of water. The soil is only moderately retentive of water, but it holds sufficient moisture to carry crops through ordinary periods of dry weather. The surface soil generally exhibits medium or strong acidity, the material below a depth of 2 or 3 feet has a less acid reaction, and the substratum commonly contains sufficient calcium carbonate to effervesce with acid or at least to give an alkaline reaction. According to local standards, the soil is of medium fertility.

Bellefontaine sandy loam is developed both in fairly large and in small areas. The relief is characterized by ridges, knobs, or hills and hollows. The gradient of most of the slopes ranges from 5 to 10 percent but in places is 25 or 30 percent. Very little of the land is so steep as to be nonarable, but slopes exceeding 10 percent are susceptible to gullying and sheet erosion when placed under cultivation, unless carefully managed. In practically all of the areas shown on the map, local variations, governed by the relief, occur in the cultivated soil. The normal soil occupies the nearly level land; considerable erosion resulting in loss of the original surface soil and exposure of the underlying clay, or even of the limy sand and gravel, occurs on the steep slopes; and at the bases of slopes or in depressions the soil is either deepened and enriched or is covered with coarse unproductive wash. Variations include small spots of deep sand similar to the Coloma soils, of clayey soil similar to the Miami soils, and of dark sandy wash, peat, or muck in small depresssions, which cannot be separated legibly on a small-scale map.

Good yields of all the common farm crops, also potatoes, melons, and small fruits, can be obtained on the smoother land. This soil also constitutes fair land for orchards, except on the steeper eroded slopes and in the wet depressions. The variations in relief and the associations of muck swamps and lakes are unfavorable conditions for the successful extensive use of the land for general farming, although high average yields are obtained in small selected fields. About 25 percent of the cleared and once-cultivated land has been abandoned for crops. About 20 percent of the entire area comprises remnants of the original forest or is in second-growth wood lots. Under present conditions, much of the land is best suited for forestry, permanent pasture, game propagation, and recreational uses.

The more level land is easily plowed, can be maintained in good tilth, and remains productive with ordinary care in management, but the steeper slopes are susceptible to destructive erosion and soon deteriorate. The soil responds to the application of commercial fertilizers, and liming is generally advisable, although on the more eroded slopes the soil contains sufficient lime to produce a good growth of sweetclover or alfalfa. On these steeper slopes, maintenance of the supply of organic matter and prevention of erosion by cover crops and other means are most important in soil management. Contour farming and terracing are impracticable in many places on the steeper slopes, because of their shortness and frequent change in direction.

Bellefontaine loamy sand.—Bellefontaine loamy sand is very similar to Bellefontaine sandy loam and Fox sandy loam, but in general the soil is sandier, more gravelly, and includes greater variations in texture and in thickness of and depth to the underlying reddish-brown gritty clay. The underlying glacial drift consists either of unevenly stratified sand and gravel or of a heterogeneous mixture of calcareous sand, gravel, silt, and pockets of clay.

In many places this soil occupies narrow embankmentlike ridges, or hogbacks, with smooth but steep slopes, and in other places a complex of gravelly knolls, oval ridges, and small basins.

Bellefontaine loamy sand has only a small value for general farming, because of its variable character, occurrence in small isolated bodies, steep slopes, and susceptibility to erosion. Much of it has been excavated for gravel. It supports a fair cover of alfalfa and sweetclover, but only a few small selected bodies are suitable for tilled crops.

Fox sandy loam.—The greater part of the soil underlain by sand and gravel on the comparatively dry smooth plains of both upland and valleys has been mapped as Fox sandy loam. This soil consists of (1) a 6- to 8-inch light-brown sandy loam plow soil; (2) pale yellowish-brown friable sandy loam from 6 to 15 inches thick; (3) a layer of sand and gravel held firmly together by reddish-brown clay and underlain abruptly, at a depth ranging from 24 to 36 inches, by (4) stratified coarse sand or sand and gravel, which is pervious and comparatively dry to a depth of several feet.

A distinguishing characteristic of Fox sandy loam is the underlying reddish-brown clayey layer. Although the proportion of clay is small, sufficient is present to bind the coarser material into a coherent mass and render the layer less pervious and more retentive of moisture than the material above or below it. The proportion of organic matter, or humus, in the virgin soil is not high, and coloration from this material extends to a depth of only 2 or 3 inches. The cultivated soil is only moderately fertile, but, according to chemical analyses made of this soil in southern Michigan, it is not abnormally low in any of the commonly determined elements of fertility. The surface soil seems to be low in calcium, but this element is more abundant in the reddish-brown clayey layer, and it is very abundant, mainly in the form of calcium carbonate or limestone pebbles, in the gravelly substratum. The reaction to a depth ranging from 2 to 3 feet is commonly acid, the surface layer being medium or strongly acid, the second layer strongly acid, and the third layer ranging from acid to alkaline. The substratum contains a large quantity of limestone

pebbles and sand grains and is alkaline. The average content of moisture is low or only medium. The reddish-brown clayey layer may become moderately compact when dry, but it does not prevent penetration of the roots.

Typically, areas of this soil are nearly level or only slightly undulating, but some of the larger bodies are pitted with shallow dry depressions and dotted or intersected by swamps. Much of the soil occurs as small islands, ranging from 10 to 30 feet in height, within swampy plains and valleys.

The larger bodies are used principally for general farming. Where the soil is liberally manured, fair yields of corn, potatoes, oats, beans, and hay crops may be obtained. Ordinarily rye does better than wheat, timothy and clover yields are somewhat less than on the heavier soils, and alfalfa and sweetclover are fairly successful. Orchard fruits and some small fruits do well. Many of the smaller bodies are of little agricultural value because of their size, location, and association. Some of this land remains in wood lots or forest, and some of it, once under cultivation, is abandoned or is used only for pasture.

Lack of moisture in the middle or latter part of the growing season is probably the chief factor limiting the production of crops. The greater part of the land at present is also deficient in organic matter. Liming is considered advisable in general, although in places excellent stands of alfalfa are growing on unlimed land, where the roots of the plants have penetrated into the more limy substratum. Experience indicates that commercial fertilizers can be used profitably for practically all the crops commonly grown.

A few areas, not indicated separately on the map, are characterized by a floor of heavy clay at a depth of 5 to 6 feet, and the soil in such areas is more productive than typical Fox sandy loam. Also, spots in which the underlying red clay subsoil is weakly developed or absent, are included on the map, and in such places the soil is similar to the Oshtemo or Plainfield soils. The soil on the steeper slopes and in the bottoms of the shallow depressions does not conform to the typical soil.

Fox loam.—Fox loam is very similar to Fox sandy loam, except that the underlying reddish-brown layer is a little heavier or lies nearer to the surface and the plow soil is slightly heavier and darker colored. This soil consists of (1) a plow soil of light grayish-brown friable loam, 6 to 8 inches thick; (2) pale-yellow or grayish-yellow sandier or less loamy material, ranging from 4 to 12 inches in thickness; (3) a dark brownish-red or reddish-brown clayey layer, which is very variable, but generally ranges from 10 to 18 inches in thickness and consists of sand and gravel cemented by sticky reddish-brown clay; and (4) unconsolidated sand and gravel, including a rather large proportion of limestone.

This soil is moderately retentive of moisture. The clayey layer becomes somewhat hard when dry but is not impervious and does not prevent the penetration of plant roots. The upper two layers are generally acid, but coarse particles of limestone are present in places. The substratum is alkaline. The soil is of medium natural fertility.

This soil occupies only a few small areas, some of which are nearly level and some uneven, owing to the inclusion of pot holes. Where the deeper depressions occur, slopes of 10 to 25 percent are common

and are susceptible to destructive erosion when placed under cultivation. The land is well drained naturally, even in the level areas, because of the coarseness and perviousness of the substratum.

The greater part of the land is under cultivation, and fair yields of corn, oats, rye, clover, and alfalfa are obtained. Special crops such as cabbage, cantaloups, cucumbers, and small fruits, are grown.

Applications of barnyard manure and rotation of crops are important in maintaining productivity. Commercial fertilizers are not used extensively but apparently cause increased yields. Probably this soil would be benefited by liming. No especial difficulties in tillage are experienced. Here and there the land is gravelly or cobbly, especially on slopes where considerable erosion has taken place.

WELL-DRAINED VERY SANDY SOILS

The well-drained very sandy soils, which occupy only 5.3 percent of the total area, are loosely coherent, low in humus, light-colored, low in moisture-holding capacity, and low or only intermediate in natural fertility. Further disadvantages are the difficulty of obtaining a firm seedbed, as compared with the heavier soils, and susceptibility to blowing under cultivation, unless protected. Their advantages are ease in plowing, early warming in spring, rapid growth of plants when supplied with moisture, and especially favorable texture and other features for the production of early potatoes, melons, berries, certain flowers, and nursery plants and for poultry farming.

Coloma loamy sand.—Coloma loamy sand comprises the dry yellowish-brown very sandy soils of the hilly or more strongly sloping areas. A profile of the virgin soil shows (1) a surface layer of sandy mold or humous soil 2 or 3 inches thick; (2) light grayish-brown sand, from 1 to 4 inches thick; (3) dull-yellow loamy sand, ranging from 10 to 20 inches in thickness, grading into (4) paler yellow incoherent sand; and (5) unaltered sandy drift, which occurs at a depth ranging from 3 to 5 feet. The plow soil is light grayish-brown loamy sand with a loose consistence. The subsurface layer of sand contains a small quantity of clay but not sufficient to bind the soil into a strongly coherent mass. The deeper underlying material is predominantly sand but is composed in part of sand containing laminae of clay and silt, lenses of clay, and various quantities of gravels and boulders. The more heterogeneous composition of the substratum distinguishes this soil from Plainfield loamy sand.

This soil is pervious and penetrable throughout. Water moves freely through it, and free and extensive root development is possible. The normal quantity of moisture held is comparatively low, but apparently a high proportion of it is available for the use of plants. The fertility is rather low or only medium. The reaction in most places is medium or strongly acid to a depth ranging from 3 to 4 feet, but calcium carbonate, in the form of either disseminated fine particles or conspicuous veining and cementation, appears in places in the substratum below a depth of 4 to 5 feet.

Coloma loamy sand occupies hummocky or hilly areas characterized by smooth slopes, broad swales, and shallow pitlike depressions. The total area mapped is not large, but a considerable aggregate area not mapped separately is included in very small bodies with Bellefontaine sandy loam and Hillsdale sandy loam. Drainage is

free, both because of the slope and the perviousness of the soil material.

Originally all this soil was forested, principally with black oak, white oak, and red oak, together with some hickory, hard maple, beech, and other species commonly present on the associated soils.

In general, the agricultural value of this soil is low, but, where the land is well manured and fertilized, fair yields of corn, small grains, and potatoes can be obtained. Grain and hay do not yield so well as on the heavier soils, although fair yields of alfalfa can be obtained. Apples, pears, peaches, cherries, plums, bush fruits, and melons return fair yields, although it is very questionable whether commercial orchards would be successful. Some of the land remains in forest or wood lots, and much of the cleared land is abandoned or is used for pasture.

In the management of this soil, experience demonstrates that it is most essential to maintain a good supply of organic matter either by using barnyard manure or by turning under green crops. The soil is subject to erosion by water on steep slopes under cultivation and to blowing by wind unless proper precautions are taken, such as compacting by heavy rollers or cultipackers and the maintenance of cover crops. The soil responds to commercial fertilizers, and applications ranging from 200 to 300 pounds of complete fertilizers, together with a top dressing of nitrate of soda, have proved effective and profitable. Applications of lime will greatly increase the probability of establishing successful stands of alfalfa and sweetclover.

Ottawa loamy fine sand.—Ottawa loamy fine sand comprises comparatively dry very sandy soil in both level and gently rolling areas. The soil is similar to Plainfield loamy sand and Coloma loamy sand, but it differs from those soils in the presence of a layer of massive clay or fine-textured material, at a depth ranging from 3 to 6 feet, which stops or retards the downward movement of water. Deep-rooted plants may make a better growth than on the other two soils mentioned.

The surface soil is acid, light-colored, low in organic matter, and low to medium in productiveness. Much of the land has been cleared and is now used for general farm crops and special crops, such as melons and small fruits. The occurrence of the soil in small bodies in association with dissimilar soils, such as heavy clays and muck, and its susceptibility to wind erosion are unfavorable conditions for its extensive use for agriculture.

Plainfield loamy sand.—Plainfield loamy sand comprises dry yellowish-brown loamy sand soils occurring on nearly level land. Clay is scarcely noticeable in the subsoil, and loose dry sand or sand and gravel extend to a depth of several feet. The 6- or 7-inch layer formed by plowing consists of light grayish-brown loose loamy sand, which is low in organic matter.

The water-holding capacity is low, and the average amount of moisture held in all layers is less than in the other sand soils. As this soil is loose and easily penetrable to a depth of several feet, it allows free development of roots. The reaction is moderately or strongly acid to a depth of 3 to 4 feet, and the substratum, or parent material, contains less limestone and other basic rocks and minerals than that of other soils. The natural fertility is low, so far as can

be determined from the experience of farmers and from chemical analyses.

Liberal manuring or turning under of green crops is most essential for the increase of productiveness. Liming is advisable, especially for alfalfa. The soil responds readily to the use of fertilizers, when rainfall is sufficient. Compacting the soil by rolling or using cultipackers is advisable for some crops and also lessens loss from blowing.

This soil is fairly uniform and true to type. Some of it, however, is a little darker and more moist than the typical soil and represents a soil very similar to Berrien loamy sand. In other places the differences between this soil and the Oshtemo and Ottawa soils are probably of little significance in regard to agricultural use and value at present. Only a few small areas are mapped, chiefly in the southeastern part near Stockbridge.

The greater part of the land is at present or has been in the past under cultivation. The staple farm crops are grown, but the yields average much less than on other soils, even where the land is heavily manured and fertilized. Lack of moisture is one of the chief limiting factors, as corn and other crops return fair yields during a wet year. The land is suitable for poultry farms. Dewberries, blackberries, raspberries, strawberries, melons, cucumbers, and the common garden vegetables can be grown with fair success. Irrigation, generally by overhead sprinkling, is necessary for high yields.

Oshtemo loamy sand.—Oshtemo loamy sand is intermediate in character between Plainfield loamy sand and Fox sandy loam. The surface soil is light grayish-brown loosely coherent loamy sand or sandy loam. At a depth ranging from 15 to 30 inches this material is underlain in most places by light reddish-brown or reddish-brown friable sandy clay loam, which rests on loose gray sand or sand and gravel. The underlying reddish-brown clayey layer is less compact and thick than that underlying the Fox soils. This soil as mapped is not uniform and includes some soil similar to the Plainfield and Fox soils, but, on the whole, it is intermediate between the two.

This soil is acid in the surface layers and is medium or low in average productiveness. Low average moisture throughout the growing season is the principal limiting factor in crop growth. The land is level and the soil easily tilled, and it is probably better adapted for small farms and special crops under intensive cultivation. A considerable part of it remains as woodland and pasture.

Berrien loamy sand.—Members of the Berrien series comprise deep sandy soils on level land, which are neither excessively dry nor wet but occupy an intermediate position between Plainfield loamy sand and the Maumee and other swampy sandy soils, in respect to content of organic matter and average moisture conditions. This soil in a representative area consists of (1) grayish-brown loamy sand or dark-brown sandy loam in the plow soil; (2) yellowish-brown or dark-brown loosely coherent sand or sandy loam, grading at a depth ranging from 20 to 30 inches into (3) gray and yellow or rust-colored mottled sand or sandy loam, in which the mottling indicates high average moisture conditions and incomplete aeration and oxidation; and (4) a deep substratum, which may be either clay or water-logged sand.

Berrien loamy sand is medium acid in reaction to a depth of 3 feet or more. It is low or only medium in natural fertility but is slightly higher in productivity than Plainfield loamy sand because of its higher moisture content. Two variations, based on the dominant texture, one a fine sand and one a medium or coarse sand, occur, of which the finer sand is the more productive. Only a few small areas of the Berrien soil are shown on the map, but a considerable aggregate area is included with other soils as very small spots in depressions and as narrow transitional strips where dry sandy soils border swampland.

This soil is naturally better adapted for small fruit, early potatoes, and various special crops than for hay and grain crops, although fair yields of these may be obtained. Liming for legumes and fertilization for all crops are advisable. Compacting with rollers or other implements should be practiced in order to prevent blowing and to obtain a better seedbed.

POORLY DRAINED SANDY SOILS

The sandy soils that constitute permanently wet or swampy land under natural conditions are of three types, Granby sandy loam, Brady sandy loam, and Maumee loam. All these soils are dark. Together they cover 8.8 percent of the total area of the county and are widely distributed in small bodies. Much of the land still remains as woodland and pasture because of difficulties in drainage, but under proper management it is capable of producing good yields of both general farm crops and truck crops.

Granby sandy loam.—Granby sandy loam is a dark wet sandy soil underlain by material ranging from nearly pure sand to sandy clay or alternating layers of sand and clay. The content of organic matter is not sufficient to constitute a sandy muck, the texture is sandier, and the amount of clay in the subsurface soil, to a depth of 3 to 4 feet, is less than in other dark wet soils, such as the Brookston, Conover, and Brady. Under natural conditions, waterlogged sand or wet gray, yellow, and rust-colored very sandy clay lies from 1 to 2 feet below the surface. This wet sandy soil is somewhat more extensive and widely distributed than the soil map indicates, as a very narrow transitional strip borders most of the muck deposits associated with upland sandy soils, and small included bodies are in most of the larger areas indicated as Brookston, Brady, and Conover soils.

The surface soil is variable but for the most part is only slightly acid or nearly neutral in reaction, and the underlying sandy clay in most places is alkaline. This soil is productive where adequately drained, but it is less durable under cultivation than the Conover and Brookston soils. With proper drainage it is suitable for the general farm crops and truck crops and affords excellent pasture in either the drained or the undrained condition. Originally it supported a heavy stand of trees, mainly elm, ash, red maple, swamp white oak, and basswood, and much of it remains as wood lots and pasture because of the expense and difficulty of drainage.

In places are included spots of very light gray sandy soil, which is ashy in appearance when dry. It is characterized by brown or black iron oxide accretions of small shot to gravel size. Such soil

in general is only slightly productive for practically all of the cultivated crops.

Brady sandy loam.—Brady sandy loam, the most extensive member of the group of poorly drained sandy soils, comprises level semiwet land in valleys and on old glacial outwash plains. This soil consists of (1) grayish-brown or light-brown sandy loam ranging from 4 to 6 inches in thickness; (2) lighter gray sandy loam ranging from 10 to 20 inches in thickness; (3) a 10- to 20-inch layer of grayish-brown, pale yellowish-brown, and rust-colored mottled sandy and gravelly clay; and (4) the wet substratum of unconsolidated sand and gravel. This soil is moderately gravelly throughout. A deep substratum of clay is present in places at a depth of 4 to 6 feet.

Under natural conditions, the water table lies at a depth of 3 to 4 feet. The content of organic matter is medium. The soil is slightly acid or nearly neutral in reaction near the surface and alkaline in the third layer and in the substratum. This soil ranks as medium in natural fertility and in productivity under cultivation. The land is level or very gently sloping.

Brady sandy loam originally supported a heavy forest growth, mainly of elm, silver maple, ash, shagbark hickory, swamp white oak, and basswood, and parts of it are still wooded.

Where properly drained, this soil is productive of the staple general farm crops, as well as dry beans and sugar beets. Liming probably is not essential. Manure can be applied profitably, and the soil may be expected to respond to applications of commercial fertilizers, especially superphosphate. The land affords good bluegrass pasture.

Variations included with this soil consist of darker mucky soil, spots of sandy loam similar to the Granby soils, and some alluvial soil near streams. The agricultural value of such areas is probably a little higher than that of typical Brady sandy loam.

Maumee loam.—Maumee loam is a wet deep sandy soil, which is dark and contains so much organic matter in the surface layers that it approaches the character of sandy muck. Under natural conditions, gray waterlogged sand or sand and gravel is present at a depth ranging from 6 to 15 inches, and sandy clay or massive impervious clay is present at a depth ranging from 3 to 8 feet. The surface soil is mellow and loamy and is easily tilled, except when very dry, in which condition it is fluffy and incoherent and is pushed before the plow rather than turned as a furrow. The soil is fairly fertile and in most places does not require liming. It is suitable for general farm crops, although small grains are apt to lodge. It is also suitable for such special crops as mint, celery, onions, and other truck crops.

Only a few small areas are mapped, although this soil is more extensive and more widely distributed than the soil map indicates, as small bodies along the borders of nearly all of the muck and peat swamps in association with the sandier soils are included with other soils in mapping. It occurs in bodies that are not sufficiently large or uniform to have much agricultural significance, and its value is largely determined by that of the associated soils.

ALLUVIAL SOILS

Soils of the bottom lands, or those consisting of recent alluvium, lying in the flood plains of streams, occupy only 2 percent of the total area of the county and, on the whole, are less valuable as agricultural land than the better upland soils.

Griffin loam.—Griffin loam comprises poorly drained soil in the bottom lands. The surface soil, for the most part, is dark-brown or nearly black sandy loam or mellow friable loam containing a comparatively large proportion of organic matter. At a depth of a few inches the soil is characteristically mottled with rust brown or yellowish brown, indicative of poor subsurface drainage and consequent poor aeration and oxidation. The alluvial deposits, although for the most part sandy, are variable, consisting of mixtures or alternating layers of sand, sandy clay, and silt, and, in places, thin beds of muck. Some sandy muck of alluvial origin is included in mapped areas. This soil is variable in reaction, ranging from slightly acid to alkaline. It is high in natural fertility, but its total area is small. The agricultural value is not high because of poor drainage, the narrowness of the areas, and the winding courses of the valleys and streams. This soil is used chiefly for pasture and wood lots. It supports a large vigorous growth of elm, ash, soft maple, willow, basswood, sycamore, and swamp white oak, and fewer trees of other species, such as walnut, butternut, cottonwood, aspen, and hackberry.

Genesee fine sandy loam.—Genesee fine sandy loam includes the drier or naturally better drained alluvium. The material varies considerably in texture at the surface and in lithologic character with depth, but most of it is brown mellow loam or loosely coherent fine sandy loam, generally underlain, at a depth within 4 feet, by moist coherent sandy loam or sandy clay.

This soil is of high natural fertility, but, occurring as it does in narrow strips, it is not well suited to cultivated field crops, except in a few places. It affords first-class pasture land. Where it is wooded, a great variety of trees of tall vigorous growth, including elm, ash, silver maple, swamp white oak, black cherry, butternut, aspen, willow, sycamore, and basswood, make up the natural cover.

ORGANIC SOILS

Organic soils are composed dominantly of plant matter, as compared with the more common soils, which are composed dominantly of mineral or inorganic matter. Most of the muck and peat constituting the soil or the parent material of the soil has accumulated in lakes, but other deposits formed in wet situations, such as valleys representing old glacial drainageways.

The deposits, considered as soils, differ in stratigraphy, or succession of layers, in texture, structure, thickness, depth to the water table, age, degree of decomposition of plant remains, and chemical characteristics; but, on account of the great amount of time and labor involved and the small economic justification for a complete differentiation, no attempt has been made to delineate on the map all the subdivisions that it might be possible to make in a detailed classification. Five fairly well defined types of organic soil are shown on the soil map.

Shallow phases of mucks and peats, where the organic accumulation is less than 36 inches thick, were noted during the soil survey, but it was not practicable to draw boundaries for them; nor was it practicable to delineate and separate from muck narrow strips of transitional soils that occur on the margins of practically all of the swamps and wet land. These marginal soils range from shallow areas of peat and muck to narrow strips of mineral soils of the Maumee, Granby, Berrien, Brookston, Conover, and Brady series.

As a class, the organic soils are characterized by a low volume weight or low specific gravity, high water-holding capacity, high specific heat, high shrinkage on drying, generally high total nitrogen, and low potash content. They are extremely variable in lime and phosphorus content. They range in reaction from alkaline to very strongly acid. Under cultivation, the organic soils undergo change from their virgin condition much more rapidly than do mineral soils. They are peculiar as soil, in that they are combustible, and in many places the original soil has been changed completely by fire. Under cultivation, those soils composed of nearly pure organic matter lack coherence at the surface when dry and are subject to blowing. The organic soils represent 15.3 percent of the area of the county.

Carlisle muck.—Carlisle muck is characterized by dark-brown or black surface material, a natural coarse-granular structure, and a fine texture under cultivation. In the typical soil the organic matter becomes finer in texture at a depth of a few inches, is pasty when wet, and when dry is hard and horny, breaking with an angular or conchoidal fracture. At a depth ranging from 12 to 20 inches the material in most places becomes coarser, more peaty, and less decomposed, and in many places it is not distinguishable from that underlying other organic soils. In Carlisle muck, the parent organic material, to a depth ranging from 12 to 20 or more inches, has been so greatly modified in most places that the original vegetal matter cannot be determined.

Carlisle muck is characteristically medium acid to alkaline in reaction. Analyses of samples from various parts of the State indicate that it is comparatively rich in lime and phosphorus but poor in potash. In places, an excess of soluble salts of calcium and magnesium accumulate in cultivated areas and damage the growth of some truck crops. The content of ash and foreign mineral matter generally is higher than in the other organic soils, except the alluvial type, Kerston muck; although, in general, as much as 75 percent of the material is volatile or combustible matter. Throughout the greater part of the county the deposits are more than 3 feet thick. Most of the shallower deposits are underlain by clay or sand and in many places by marl.

Carlisle muck originally was forested, and a considerable part is still covered by trees, of which elm, ash, red maple, and swamp white oak are the dominant species, in addition to some aspen and willow.

In some of the areas mapped as Carlisle muck, inclusions are made of other organic soils, such as Houghton muck and Rifle peat. Also, in many places, the original character of Carlisle muck has been greatly altered by burning, which has resulted in depressions where the soil is ashy or excessively alkaline, and the underlying sand or clay is exposed.

Carlisle muck is very extensive, but only a small proportion is cultivated. Where adequate drainage is provided and proper cultivation and fertilization are practiced, this land is especially suited to such crops as celery, onions, cabbage, carrots, sugar beets, and mint. General farm crops, such as corn, small grains, and potatoes, are less successful. Bluegrass, timothy, alsike clover, and redtop furnish good pasture on the cleared or partly cleared land, especially where the deposit of muck is shallow.

Drainage and control of the height of the water table are most important in the efficient utilization of this soil for cultivated crops. Large applications of commercial fertilizers carrying a high percentage of potash are necessary in most places, and compacting of the soil with a roller is, in most places, advisable.[5] As on all muck or peat soils, cultivated plants are more susceptible to damage from frost than on adjacent mineral soils.

Houghton muck.—Houghton muck has a dark-brown or nearly black finely fibrous surface layer and therefore differs in texture from Rifle peat and Carlisle muck. In some places this fibrous material consists simply of a dense tough mat of the roots of grasses and sedges. At a greater depth the underlying deposit in places is very similar to that under the other organic soils, or, in shallow deposits on sites that have always been marshland, the fine fibrous peat continues uniform with depth and rests on a dark-gray pasty or gelatinous deposit over the mineral substratum. The deposits are nearly pure organic matter. The water table is high, and decomposition is only moderate. The surface soil is only moderately acid—in places is nearly neutral in reaction.

Only a small total area of Houghton muck is mapped. The land supports a growth of sedges and bluejoint, with only a few scattered trees and shrubs, such as tamarack and willow. Most of it is not used or is used only for wild marsh hay and for pasture. Like Carlisle muck and Rifle peat, this land is capable of being successfully utilized for the production of truck crops under skillful management, including control of the water table and intelligent use of commercial fertilizers. The pasture value is less than that of Carlisle muck.

Rifle peat.—Rifle peat occupies an intermediate position between Carlisle muck and Greenwood peat in average depth to the water table and state of decomposition of plant matter. The surface soil is granular, woody, and loamy, and nearly black or dark brown, but it does not show very much decomposition below a depth of 6 or 8 inches, where the material is coarse in texture and either woody or fibrous, or a feltlike and spongy mass. This type of organic material presents a greater range in reaction than Carlisle muck or Greenwood peat, but it is not so strongly acid as Greenwood peat and is neutral or alkaline in few places, except where burned. Most of the deposits are more than 3 feet thick.

In this county, Rifle peat is characterized by a growth of tamarack, elm, and aspen, together with such shrubs as red-osier dogwood, winterberry, chokeberry, dwarf birch, elderberry, and huckleberry. In places where trees have disappeared, because of fire or other agencies, the soil supports a dense growth of sedges and grasses, principally wire grass and bluejoint. The surface soil in such places becomes, in time, similar to that of Houghton muck, but it is underlain by the trunks and roots of trees.

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[5] More complete information as to the management of muck soils in Michigan can be obtained from the following publications:

McCool, M. M., and Harmer, Paul M. The muck soils of Michigan. Their management for the production of general crops. Mich. Agr. Expt. Sta. Spec. Bul. 136. 78 pp. illus. 1925.

Harmer, Paul M. Muck soil management for onion production. Mich. Agr. Col. Ext. Bul. 123, 27 pp., illus. (Revised.)

Harmer, Paul M. Methods of conserving Michigan muck soils. Mich. Agr. Expt. Sta. Quart. Bul. 19: 182–191. 1937.

Michigan Agricultural College, Soils Department. Fertilizer recommendations for 1937. Mich. Agr. Col. Ext. Bul. 159, 24 pp. illus. 1937. (Revised.)

Rifle peat is widely distributed in small and large areas throughout the county. Very little attempt has been made to drain the land or to utilize it for agricultural purposes, other than to a small extent for pasture and wild hay. Where properly drained, thoroughly cultivated to produce a good tilth, and properly fertilized, this organic soil has been successfully used for truck crops. It is less suitable for corn, small grains, and other general farm crops. The cost of reclamation, in general, may be expected to be somewhat higher than for Carlisle muck, and somewhat more time and greater cost are involved in obtaining a good tilth and bringing the soil to equal productiveness for the common truck crops. Much of the land yields an income from native huckleberries and blueberries.

Greenwood peat.—Greenwood peat is yellowish brown or reddish brown, coarse textured, incompact, fibrous, spongy, and feltlike. It shows very little decomposition of the parent plant material and has a very low ash content. The average depth of the water table is only a few inches below the surface under natural conditions, but it fluctuates considerably. This soil is very strongly acid in reaction, and analyses of samples from different parts of the State indicate that probably it is generally very low in content of lime and phosphorus.

Most areas of Greenwood peat are characterized by a growth of leatherleaf, blueberry, huckleberry, kalmia, chokeberry, sedges, and sphagnum and hypnum mosses. Trees, such as aspen and tamarack, are smaller than on Rifle peat and Carlisle muck. Only a very few small areas of this soil are mapped. It is not regarded as having much agricultural value.

Kerston muck.—Kerston muck represents a soil condition occurring in the flood plains of the larger streams. Mineral matter of alluvial origin is mixed with the organic matter in proportions ranging from 50 to 75 percent, either in disseminated form or in separate layers of deposition. The organic matter, for the most part, is dark and resembles that of Carlisle muck. This soil grades into the alluvial mineral soil designated as Griffin loam, and in places the distinction between the two is not sharp.

In places little soil difference is noted in the muck of the stream valleys from the other types, designated as Houghton muck, Carlisle muck, and Rifle peat, other than the inclusion of a little more mineral matter, or in the alluvial character of the substratum.

The soil in the areas shown is medium to high in fertility and for the most part is alkaline in reaction. The wet condition of the land, its topographic situation, and the shape of the areas preclude any extensive use other than for pasture, woodland, or, in very small fields, for truck crops.

PRODUCTIVITY RATINGS

The soils of Ingham County are rated in table 5 according to their productivity for the more important crops. The ratings are based on the prevailing farm practices. The figures as given do not apply where soils have been allowed to deteriorate, because of erosion, or where drainage systems have not been properly maintained. In evaluating individual soil types, as mapped, the uniformity of the type, the size of separate bodies, and the particular association are also modifying factors. The descriptions given in the preceding pages should be consulted.

TABLE 5.—*Productivity ratings of soils in Ingham County, Mic*

Soil [1]	Crop productivity index [2] for—																										
	Corn (grain)		Corn (silage)		Wheat		Oats		Rye	Mixed timothy and clover		Red clover		Alfalfa		Beans		Sugar beets		Potatoes		Vegetables (leafy) [3]		Vegetables [3]		Small fruits [2]	
	A	B	A	B	A	B	A	B	A	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	
Conover loam [6]	90	100	90	100	80	100	90	100	80	90	100	90	100	70	90	80	100	70	90	50	70	60	---	70	90	60	
Brookston loam, drained.	90	100	90	100	80	100	90	100	80	90	100	90	100	60	90	80	90	70	90	40	60	70	---	70	90	50	
Miami loam	80	90	80	90	70	100	80	90	80	70	90	70	90	60	90	70	90	60	80	60	80	50	---	60	80	80	
Genesee fine sandy loam.	80	90	80	90	70	80	80	90	80	90	100	90	100	70	90	70	90	70	90	70	90	80	---	80	100	70	
Washtenaw loam [6]	80	90	80	90	70	80	80	90	80	90	100	90	100	70	90	80	90	70	90	40	80	90	---	80	100	60	
Griffin loam, drained and protected from overflow.	70	90	80	90	70	80	80	90	80	90	100	90	100	70	90	70	90	70	90	60	80	90	---	80	100	60	
Brady sandy loam [6]	70	90	70	90	70	80	80	90	70	80	90	70	90	60	70	70	90	70	90	40	70	70	80	70	90	60	
Maumee loam, drained.	70	80	70	90	70	80	80	90	70	70	90	80	90	50	70	70	90	60	90	40	80	70	90	70	90	70	
Granby sandy loam, drained.	70	80	70	90	70	80	80	90	70	70	90	80	90	50	70	70	90	60	90	40	80	70	90	70	90	70	
Hillsdale sandy loam [8]	60	80	60	80	60	80	70	90	80	60	90	50	80	50	80	60	90	50	70	60	90	50	---	60	80	80	
Fox loam	60	80	60	80	70	90	80	90	80	70	80	60	70	50	70	60	80	50	70	60	90	40	---	40	70	80	
Fox sandy loam	50	70	50	70	60	80	60	70	70	50	70	40	70	40	60	50	70	---	---	60	80	40	---	50	70	80	
Bellefontaine sandy loam. [8]	50	70	50	70	60	80	60	70	70	50	70	50	80	40	70	60	80	40	60	60	80	50	---	60	80	80	
Berrien loamy sand	50	70	50	70	40	60	50	70	60	60	70	40	70	40	70	40	70	---	---	40	80	60	---	60	80	80	
Ottawa loamy fine sand.	40	50	40	60	40	60	40	60	50	50	60	30	60	30	50	40	60	---	---	40	60	40	---	40	60	80	
Carlisle muck, drained	---	---	70	90	---	---	---	---	60	50	100	---	---	---	50	---	---	30	80	30	70	80	100	80	100	60	
Kerston muck, drained	---	---	70	90	---	---	---	---	60	50	100	---	---	---	50	---	---	30	80	30	70	80	100	70	100	60	
Wallkill loam, drained	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	70	---	70	80	---	
Houghton muck, drained.	---	---	---	---	---	---	---	---	---	40	90	---	---	---	---	---	---	10	70	---	70	70	90	70	90	60	
Rifle peat, drained	---	---	60	80	---	---	---	---	---	40	90	---	---	---	---	---	---	10	70	---	---	70	90	70	90	60	

Bellefontaine loamy sand.[5]	40	60	40	60	30	50	40	60	60	50	60	40	60	30	50	40	60	---	---	50	70	30	---	40	60	70		
Oshtemo loamy sand	40	60	40	60	40	50	40	60	60	40	60	30	60	30	50	40	60	---	---	40	70	40	---	40	60	70		
Coloma loamy sand [8]	40	60	40	60	30	50	40	50	50	40	60	30	50	30	50	40	60	---	---	50	70	30	---	40	70	70		
Plainfield loamy sand	30	50	30	50	30	50	30	50	50	30	50	30	50	30	50	30	60	---	---	40	60	30	---	30	70	60		
Brookston loam, undrained.	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		
Carlisle muck, undrained.	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		
Granby sandy loam, undrained.	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		
Maumee loam, undrained.	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		
Kerston muck, undrained.	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		
Wallkill loam, undrained.	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		
Griffin loam, undrained.	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		
Houghton muck, undrained.	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		
Ridge peat, undrained	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		
Greenwood peat, undrained.	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		

[1] Soils are listed in the approximate order of their general productivity under the more dominant current practices, the most productive first.

[2] The soils of Ingham County are given indexes that in licate the approximate production of each crop in percentage of the standard of reference. The standard represents the approximate average yield obtained without the use of amendments on the more extensive and better soil types of the sections in which the crop is most widely grown. It should be realized that these ratings are partly inductive, as yield data by soil types are yet too fragmental to be adequate. The indexes in column A refer to yields obtained under the more common practices of management that prevail in this county and include the use of some commercial fertilizer and lime; those in column B refer to yields obtained under the more intensive or best practices that include the greater use of legumes, green manures, manures, commercial fertilizers, and improved plant varieties.

[3] These indexes are largely comparative for the soil types of this and adjoining counties and are not based on standards of reference because of insufficient data.

[4] This classification indicates the prevailing current practices (A) a grades are derived from the assigned of management exist than have been in general productivity of each soil

[5] This is a general classification to farm crops, pasture, or forestry. I classes on a map, other considerations important.

[6] The crop indexes for these soils r

[7] Only limited areas of these soils

[8] The crop indexes for these soils are included in the type separation.

The productivity of each soil for each crop is compared to a standard of 100 in the columns headed "Crop productivity index." A rating of 25, for example, indicates that the soil type is one-fourth as productive for the specific crop as is a soil with a rating of 100. A standard of 100 is meant to represent the approximate average yield of the crop obtained without the use of amendments on the more extensive and better soils in the section where the crop is principally grown. Small areas of unusually productive soils or soils given amendments, such as fertilizers or irrigation, may yield larger crops than the standard, and under such conditions ratings above 100 are given.

The following tabulation sets forth the acre yields that have been established as standards of 100. These figures represent the average long-time yields of crops of satisfactory quality on the better soils without the use of amendments.

Crop:			Crop:		
Corn (grain)	bushels	50	Corn (silage)	tons	12
Wheat	do	25	Timothy and clover hay	do	2
Oats	do	50	Red clover hay	do	2
Rye	do	25	Alfalfa hay	do	4
Beans	do	25	Sugar beets	do	12
Potatoes	do	200			

The principal factors determining the productivity of land are generally said to be climate, soil, including slope and drainage, and management. In setting up productivity ratings for soil types, consideration must be given to all these factors and an attempt made to evaluate their influence. Crop yields over a long period offer the best available summation of the combined effect of the factors, and they are used as guides in the establishment of the ratings, wherever they are available. Lacking such data, the indexes represent estimates based on observations, experience, and interviews.

All the ratings are based partly on inductive estimates rather than on reported crop yields because of the lack of definite information. Nevertheless, it is felt that the ratings do provide a fairly accurate picture of the relative productivities of the soils of the county.

Current practices in this county are considered to include the use of legumes, the return to the land of the barnyard manure produced on the farm, the use of lime for alfalfa, and the use of some commercial fertilizers.

Two ratings are given for a number of soil types to indicate the productivity under natural conditions of poor drainage and under conditions of adequate artificial drainage. In some areas tile has been laid, but drainage still is not adequate. The productivities of such areas will be intermediate between the drained and the undrained areas of the same soil type. Natural drainage on Conover loam, Brady sandy loam, and Washtenaw loam is intermediate between good and poor. Indexes for these soils are given only to the naturally better drained areas, although certain areas are artificially drained, and others are left in a comparatively wet condition.

In the column, "General productivity grade," the soils are listed in the order of their general productivity under dominant current practices. The general productivity grade is based on a weighted average of the indexes for the various crops, using the average acreage and value of those crops in the county as a basis. If the weighted average falls between 90 and 100, the soil type is assigned a grade of 1;

if it falls between 80 and 90, it is assigned a grade of 2; and so on. Since it is difficult to measure or to express mathematically either the exact significance of a crop in local agriculture or the importance and suitability of given soils for particular crops, the weightings were used only as guides, and in this county the productivity grades resulted from an inspection of the crop indexes rather than from careful computations.

The column headed "Land classification" summarizes in a simple way the productivity and use capabilities of the various soils by placing them in a few groups on the basis of their relative suitability for farming, pasture, and forestry.

Productivity-rating tables do not present the relative roles that soil types play in the agriculture of a county but rather indicate the productive capacity of each type. Total agricultural production of a soil type depends on its extent and geographic distribution as well as on its actual productivity.

Economic considerations play no part in determining the productivity indexes, which refer to production of each crop or group of crops. The indexes, therefore, cannot be interpreted into land values except in a very general way. The value of land depends on distance from market, the relative prices of farm products, and a number of other factors, in addition to the productivity of the soil.

MORPHOLOGY AND GENESIS OF SOILS

Two divisions of soils, based on the dominance of gross elements, are represented: (1) Mineral soils, developed from disintegrated rocks, and (2) organic soils, developed from peat deposits. The mineral soils comprise about 85 percent of the total land area of the county and the organic soils about 15 percent. Skeletal soils, bedrock, or unaltered geologic formations are scarcely represented.

The mineral soils are represented by the two following major taxonomic divisions, based on the average amount of water in the solum: (1) Well-drained soils; and (2) imperfectly and poorly drained (hydromorphic) soils, in which water exists permanently or for considerable periods, to the point of complete soil saturation and waterlogging. The first division is estimated as occupying about 43 percent of the total land area of the county and the second about 42 percent.

The well-drained mineral soils that have the more completely developed profiles are pedalferic and belong to the great group of Gray-Brown Podzolic soils, which are the representative soils of the central and east-central parts of the United States, largely east of the Mississippi River. They are all podzolic, in that leaching, particularly removal of calcium and magnesium carbonates, together with the translocation or removal of sesquioxides from the surface layers, is dominant in the soil-forming processes. They differ from the soils in the more northern part of the State, in the presence of larger quantities of residual clay from weathering in place in the solum, together with more intense coloring from reddish-brown ferric hydroxides in the B horizons, whereas the layer of humous soil, other factors being nearly the same, has a greater thickness. The brown humic horizon, or orterde, characteristic of the Podzols, is generally absent but in places is faintly developed or appears possibly as a relict of an early more strongly podzolic profile. Leaching of car-

bonates has taken place to a slightly greater depth than in the area to the north and to less depth than in southeastern United States. The clayey B horizon has also reached a greater thickness than in the Podzols; but, on the other hand, the amount of residual clay from weathering and the tendency toward development of a claypan are less than in the soil regions of the United States to the south and west.

The generalized profile of the virgin soil of members of this group shows the following layers: 1 (A_0), a very thin accumulation of litter and forest mold; 2 (A_1), a thin layer of dark grayish-brown humous soil; 3 (A_2), a highly leached, acid, grayish-brown or yellowish-brown layer; 4 (B), a layer of maximum coloration from ferric oxides and maximum accumulation of inorganic colloids; 5 (C), the parent material, or geologic substratum. In many places, comparatively thin transitional horizons, A_3, B_1, or B_3, may be observed.

The soils characterized by the above-described profile may be divided into three subgroups on the basis of the texture and structure of the successive layers in the profile, as follows: (1) A subgroup underlain by material high in content of clay and comparatively dense and impervious in the fourth and fifth layers of the generalized profile given above; (2) a subgroup underlain by sand and gravel or rather loose and pervious material in the fourth and fifth layers; (3) a subgroup with heavier or more clayey material in the fourth layer and less clayey and more pervious material in the fifth layer.

These groups are still further differentiated into soil series and types, on the basis of differences in color, texture, structure, chemical characteristics, and thickness of the various layers, including the parent material.

In the typical profile the surface layers of litter, mold, and humus are layers of accretion or accumulation. In the solum the process of soil formation has been dominantly one of eluviation. It is improbable that much appreciable addition to the original parent material, through translocation, has taken place in the B horizon. Some precipitation of calcium carbonate, carried downward from the surface, may have taken place in the upper part of the C horizon, or slightly altered glacial drift, as secondary incrustation, veining, and cementation are common. Whether this segregation of carbonates represents material removed from the thickness now represented by leached soil or is a purely geological phenomenon independent of soil-forming processes is debatable, although on the basis of field observation it appears that the carbonate content is actually greater in the upper part of the C horizon than in the deeper strata.

Litter and forest mold in general do not accumulate to a thickness of more than 2 inches and the humous soil (A_1) is at best only 2 or 3 inches thick. The depth to which carbonates have been removed is, in general, between 36 and 48 inches, but this differs with the amount of carbonates originally present and with the texture and topographic position of the soil. The depth of removal is less in the heaviest soils and greater in the loose incoherent sands under conditions of free downward movement of water. Where the fourth layer, or horizon of maximum concentration of clay and inorganic colloids, is sufficiently compact or impervious to impede the downward movement of water, a secondary layer, occurring between the third and fourth layers, shows the most complete leaching and the

highest degree of acidity. From the top of the fourth horizon there appears to be a gradual increase in the content of lime with depth to a place where the maximum is present in the upper part of the C horizon, or parent material.

Nitrogen and phosphorus are more plentiful in the upper two layers than in the third, and iron and alumina are most abundant in the fourth layer. Differences between the separate layers and between the solum and the parent material appear to be greater for calcium and magnesium than for the other constituents, except nitrogen, which ordinarily are determined in the total chemical analysis. Phosphorus, according to a few complete analyses and to numerous qualitative tests, occurs in many places in equal or greater quantities in the parent material than in the solum.

Mature or old soils developed under conditions of poor drainage or high moisture, known as Half-Bog soils, have the following generalized profile: (1) A dark-gray or black surface layer representing an accumulation of organic matter; (2) a gray or drab glei horizon, slightly colored by organic matter; (3) a horizon containing maximum clay and having a maximum degree of coherence or plasticity, or one containing maximum yellow or brown coloration, iron oxide, pebbles, or cementation by iron oxides; and (4) the substratum, or parent material. The same textural subgroups are present as in the soils developed under relatively drier conditions. Leaching is greatest in the second horizon, which reaches its greatest thickness in places where the parent material is sand. These soils are less completely leached of carbonates than the well-drained soils and are generally higher in fertility, measured by the total amount of nitrogen, calcium, phosphorus, and potash present, where the parent material is the same. Where the parent material is calcic, or basic, the soils commonly exhibit an alkaline or neutral reaction from the surface downward. Where the parent material is sand, the third horizon commonly exhibits a marked yellow or brown color, although the content of humic matter is less and cementation to the degree of hardpan, is less common than in other parts of the State, particularly farther north and bordering the Great Lakes.

Soils developed under intermediate drainage conditions, representing profiles in a transitional stage, are present. The Berrien and Conover soils belong to this group.

Soils having incompletely developed profiles are represented almost entirely by alluvial soils developed from recent alluvium lying in the valleys of the streams. Most of this material is of high average moisture content or occurs in swampy or semiswampy situations. The alluvium is yellowish brown, brown, and grayish brown in color and inherits its character from the local soils and glacial drift. A not uncommon feature of the deposits is alternate layers of mineral alluvium and muck. The muck or peat of these deposits is partly transported but mainly accumulated in place. A large number of very small bodies of soil represent recent slope wash, or colluvium, in basins or drainage swales. Soils having incompletely developed profiles because of excessive erosion under natural conditions (Lithosols) also are present, but these, too, are very small in total acreage. Most of such soil appears in the narrow strips of broken hilly land bordering the Grand River and other large streams.

The organic (or Bog) soils are represented by a number of types, which show considerable range in chemical and physical properties. Practically all have a high organic-matter content; that is, they contain from 50 to 75 percent or more of combustible material. Most of the deposits appear to have accumulated in lakes, although some have originated in marshes and seepage springs. Deposits on the sites of lakes reach considerable thickness, generally in excess of 4 feet and in places greater than 30 feet. Clay or sand generally underlies the peat, but marl deposits also underlie many areas. More or less complete alteration, represented by a nearly black or dark-brown color and complete destruction of the botanical character of the plant remains, in the oldest soils in places reaches a depth of 18 to 24 inches. In the most acid and peaty type of organic soil, Greenwood peat, there has been practically no alteration, although the fluctuation of the water table is as great as in the other organic soils. Most of the organic soils are moderately acid in reaction, some are comparatively high in lime and are neutral or only slightly acid, and only a very small proportion of them is very strongly acid. In most places acidity appears to depend on the height of the water table and rawness or lack of decomposition of the plant matter, as the organic soils are acid in places, despite the fact that adjacent mineral soils and glacial drift are limy and the drainage waters are alkaline. In the last analysis the family characteristics of organic soils probably are influenced by the climate, geology, and physiography of the section in which they occur. It seems probable that the oldest organic soils in this section cannot reach so complete a stage of decomposition as is attained in areas farther south, and that texture and consistence of the material differ because of differences in the plant species composing the parent material.

The lake waters that support vegetation generally are clear, with very little mineral matter in suspension, and they are generally alkaline in reaction, owing to the presence of calcium and magnesium bicarbonate. There is a wide range in hardness of the waters, from 2 or 3 grains to as much as 18 per gallon, and a number of water soil types may be recognized according to the kind of subaqueous soil, whether clay, sand, marl, or peat. The classification of these soils, however, has not been perfected. Most of the stream water, even that originating in peat and muck swamps, is alkaline and comparatively clear throughout the greater part of the year. In the most acid bogs occupied by such plants as leatherleaf and sphagnum moss, the standing water is strongly acid in reaction.

All the soil types differentiated in this county occur in a gradational series, according to the variation in the moisture or drainage conditions under which the individual soil has developed. The great diversity of soil types, their intimate association in many places in small areas, and the wide variations in all soils within short horizontal distances are traceable in part to the lithologic heterogeneity of the parent soil material and in part to the variations in thickness of comparatively pervious material over comparatively impervious clay, and the result is a wide range in moisture conditions. The topographic expression of the glacial formations, moraines, outwash plains, till plains, old glacial drainage valleys, and old lake beds also shows great diversity.

The surface geologic formations were deposited during the last stages of the glacial period, so that the land surface is comparatively young. Also the configuration features are almost entirely constructional, since streams have not yet had time to develop complete dendritic systems. Large areas, therefore, remain flat and covered with water, so that a rather large aggregate area of mineral soils developed under conditions of excessive moisture has formed, together with the accumulation of peat desposits. On the other hand, soils developed under conditions of low moisture have been possible because of the perviousness and thickness of some of the glacial deposits, notwithstanding the fact that the areas may be level. Various wet and dry conditions on the moraines are largely functions of the differences in texture of the glacial debris rather than of stream erosion or slope of land surface, whereas the generally moister condition on till plains is ascribed to the more clayey character of the deposits and to the smoother, less rolling relief.

The glacial drift is characterized by a great variety of igneous, metamorphic, and sedimentary rocks, without marked dominance of any one kind. Limestone is present in all the drift deposits, but it probably nowhere exceeds 10 percent of the total mass of coarser detritus and perhaps is generally in a much smaller proportion. Formations of Pennsylvanian age, which constitute the bedrock of this part of the State and which consist of shales, sandstones, and limestones, have exerted an indirect influence on the soils. The clay deposits in the drift are everywhere calcareous and generally exhibit a gray or slate color in the unweathered condition and a yellow and brown color where weathered. Red till clay has been observed in a few places but is not common, as this county lies from 30 to 40 miles southward from the main body of reddish-brown drift, which occupies the northern part of the State. An influence from local sandstone formations is present throughout the county, but this appears to be most pronounced in the southern part, in the vicinity of Onondaga and Leslie. The depth of the drift covering ranges from 15 to 200 or more feet; bedrock is seen in few places and nowhere directly influences the character of the soil.

The native vegetation has been of the greatest influence in the development of soil characteristics. But, as is generally true, the vegetation is both a cause and an effect of soil differences. This entire county, with the exception of lakes and marshes, which, combined, comprise only 2 or 3 percent of the total area, originally was forested. The forest cover on the loam and clayey soils was principally a dense thrifty growth of hardwoods, but on some of the plains occupied by the Fox and Plainfield soils the growth was rather open and consisted mainly of oaks. The thinness of the humous soil and the generally light color of the underlying A_2 horizon are, at least in part, attributable to the forest vegetation. The composition, texture, and other physical and chemical characteristics of the surface layers of organic soils are closely related to the vegetation they now support.

Table 6 summarizes the kind of forest vegetation that originally was present on each type of soil or land. As only about 15 percent of the county is now occupied by native vegetation, or a cover similar to it, the original cover for the county as a whole can be reconstructed only approximately.

TABLE 6.—*Relationships between soil types and original vegetation*

Soil type	Probable original cover on the larger bodies of land	Surface layers of virgin soil
Miami loam	Hardwood forest in dense stands; medium to large individual tree growth; very little herbaceous or shrubby undergrowth; dominant trees, sugar maple, beech, white oak, elm, white ash, hickory, basswood, red oak, and black oak.	Litter and leaf mat very thin, containing undecomposed woody matter; light-brown thin granular humous soil, nearly neutral or only slightly acid; light-colored leached horizon, conspicuous and strongly acid.
Hillsdale sandy loam	Oaks and hickory dominant; sugar maple, beech, elm, and cherry, few to abundant; medium-sized trees; small amount of undergrowth.	Litter and leaf mat thin; brown humous soil, granular and slightly acid; pale-yellow leached horizon, strongly acid.
Bellefontaine sandy loam, Bellefontaine loamy sand, and Coloma loamy sand.	Medium stand of trees, with oaks and hickory dominant; diversity of other species including elm, black cherry, dogwood, hophornbeam (ironwood) (*Ostrya*), American hornbeam (blue beech) (*Carpinus*), sassafras, and juniper; a few sugar maple and beech; small amount of herbaceous undergrowth; legumes.	Litter and leaf mat thin; brown humous soil, granular, neutral to slightly acid, 2 to 5 inches thick; light-colored leached horizon, strongly acid but not conspicuous in the sandier soil.
Fox sandy loam, Fox loam, and Oshtemo loamy sand.	Open stand of medium-sized trees; red, white, and black oaks and hickory dominant; herbaceous undergrowth.	Litter and leaf mat thin; brown humous soil, 2 to 3 inches thick, neutral to mildly acid; strongly acid leached layer but not conspicuously light in color.
Plainfield loamy sand	Open growth of medium-sized to small trees; oaks dominant; herbaceous undergrowth.	Very little or no leaf mat; brown humous soil, neutral to slightly acid; none or very thin gray leached layer.
Ottawa loamy fine sand	Medium stand of trees, with oaks dominant; diversity of other species; small amount of herbaceous under growth.	Very little or no leaf mat; brown humous soil, neutral to slightly acid.
Berrien loamy sand	Oaks dominant; white oak, red oak, hickory, beech, red maple, and aspen.	Very thin leaf mat; neutral to acid thin gray leached layer; suggestion of brown or terde.
Brookston loam and Brady sandy loam.	Dense stand of tall and large individual trees, mainly elm, silver maple, ash, basswood, shagbark hickory, and swamp white oak; vines; few shrubs; very little herbaceous undergrowth.	Very thin or no leaf mat; thick coarsely granular humous soil, alkaline to neutral; no ashy leached layer. (Thick layer of humus probably inherited from a previous marsh or muck condition.
Conover loam	Elm, ash, basswood, oaks, hickory; fewer beech, sugar maple, walnut, and butternut.	Little or no leaf mat; dark-brown granular humous layer, alkaline or very slightly acid; leached ashy layer not strongly developed.
Maumee loam and Granby sandy loam.	Elm, ash, swamp white oak, sycamore, cottonwood, aspen, red maple; considerable shrub and herbaceous growth; grasses; *Carex; Juncus;* and other vegetation.	Black or dark-gray humous soil, alkaline or not strongly acid; some coarse woody matter on the surface, but organic matter probably inherited from recent marsh or muck swamp condition.
Griffin loam and Genesee fine sandy loam.	Elm, ash, and silver maple dominant; sycamore, cottonwood, cherry, walnut, butternut, tuliptree, basswood, hackberry, aspen, and willow, common; vines; shrubs; grasses; herbaceous plants.	Very little or no influence from present vegetation.
Washtenaw loam and Wallkill loam.	Elm, black ash, green ash, red maple, willow, swamp white oak, walnut, and butternut; shrubs and herbaceous vegetation.	Do.
Carlisle muck and Kerston muck.	Elm, ash, red maple, willow, aspen, swamp white oak, and basswood; shrubs; vines; herbaceous vegetation; ferns.	Granular black surface soil, woody soil in part.
Rifle peat	Tamarack, aspen, red maple, elm, an occasional black spruce and paper birch (white birch); shrubs, such as *Vaccinium*, chokeberry, *Cornus*, and others, abundant; sedges; grasses.	Woody and fibrous.
Greenwood peat	Bogs of leatherleaf, sphagnum and other mosses, and sedges; some tamarack, aspen, red maple, and shrubs.	Coarse and fibrous raw peat, highly acid.
Houghton muck	Marsh type of vegetation; grasses and sedges dominant; shrubs, such as *Potentilla*, *Cornus*, black birch, scattered tamarack, and willows.	Finely fibrous matted dark surface soil.

It is evident that a single species of plant may be widely distributed and grow on a large number of individual soils, but differences exist in its relative abundance, its form, and its rate of growth. It appears that oaks were most abundant on the deeper and drier sandy soils; sugar maple and beech on the clayey soils and soils of intermediate texture, medium to high in fertility, and fairly well to well drained; elm, ash, basswood, shagbark hickory, swamp white oak, and silver maple on the heavier textured and darker colored sandy loam to clayey soils under poor drainage; aspen, tamarack, birch, and black spruce were almost entirely restricted to muck and peat soils; sycamore, cottonwood, tuliptree, hackberry, walnut, and butternut grew most abundantly on alluvial soils, but some of these species also grew on the darker more limy semiwet loams and sandy loams of the upland.

Influence on the soils from types of vegetation that preceded the present may be assumed, although too little is known about the histology of the soil profile for a statement of the specific nature of such influence to be made, except as regards the peat deposits and organic soils. Geologic and physiographic situations very similar to those in southwestern Michigan, where remnants of prairies and very dark brown thick humous soils exist, occur in this county. It is therefore highly probable that prairies also existed here, but, if so, the Prairie soil profile has been completely effaced by subsequent forest cover.

In the evolution of the soils from the glacial deposits, under the forest vegetation, the dominant process has been leaching of soluble matter and translocation of colloids. Some accumulation of clay from weathering in situ has taken place, but this is less than in the older unglaciated regions of the United States. The more gravelly and calcareous deposits show abundant evidence of the formation of clay by postglacial weathering, but most of the clay in such soils as the Miami is inherited directly from the parent material. The progressive changes in the soil profile probably are toward continued leaching and, possibly, toward an increase in thickness of the solum. Such an assumption, however, does not necessarily imply any change in the relative thicknesses of the A and B horizons of the oldest soils, as in very few places is there any evidence of the destruction of profiles through geological erosion. When normal erosion balances the rate of soil formation, the soil may be said to have reached an equilibrium with the environment. Whether or not this point has been reached is uncertain. There are a few small areas of more highly podzolized soils having profiles characteristic of more northern humid regions and some purely local changes caused by rise in the water table. In a few places the accumulation of peat has been continuous, but, on the whole, the physiographic change has been toward drainage of existing wet land and, therefore, toward decrease in the area of muck, a change of muck to mineral soil, and the wet mineral soil to the climax, or zonal, profile. Soils having a zonal, or climax, profile occupy about 60 percent of the total area of the county.

SUMMARY

Ingham County is in the south-central part of the Lower Peninsula of Michigan and includes a total area of 553 square miles, or 353,920

acres. It had a population in 1930 of 116,587, about two-thirds of which was urban.

The climate is continental, with cold winters and mild summers, and the average annual precipitation is 31.43 inches. The average frost-free season is 160 days, but this period is shorter on the muck lands and in the pot-hole basins. Precipitation is so distributed that it is sufficient for high production of crops, and the snowfall generally is sufficient to give some protection to winter grain crops.

The present-day agriculture is of three types: (1) General farming; (2) general farming combined with the production of some special cash crop; and (3) the production of specialties, such as poultry, fruit, truck crops, and flowers.

On the basis of drainage and texture the soils may be placed in seven groups, which are described as follows:

(1) The well-drained clayey soils are represented only by Miami loam and its various minor phases and variations, which are not differentiated on the soil map. This soil is especially well suited to general farming.

(2) The imperfectly and poorly drained clayey soils include Conover loam, Brookston loam, Washtenaw loam, and Wallkill loam. All these soils must be drained in order to produce good crops, and they are very productive when drained. They are used most extensively for the production of general farm crops. The undrainable areas remain in forest.

(3) The well-drained loamy and sandy soils are Hillsdale sandy loam, which is especially well suited to general farming and to a limited extent for orcharding; Bellefontaine sandy loam of medium fertility, which is used for general farming but is less productive than the Miami and Hillsdale soils because of its rolling relief and leachy parent material; Bellefontaine loamy sand, which has very little agricultural value and is exploited mostly for gravel; Fox sandy loam, which is used principally for general farming, but is less productive than Miami loam; and Fox loam, which is superior to the sandy loam.

(4) The well-drained very sandy soils include Coloma loamy sand, Ottawa loamy fine sand, Plainfield loamy sand, Oshtemo loamy sand, and Berrien loamy sand. These soils are too sandy and, therefore, too leachy to be well suited to agriculture, but most of them will produce crops if heavily manured, fertilized, and irrigated during dry periods. Berrien loamy sand is less subject to drought than the others because of its imperfect drainage. Special crops, such as vegetables, berries, and some fruits, are produced on very small areas of the very sandy soils, but hay and grain are much less productive on them.

(5) The poorly drained sandy soils must be artificially drained before they can be used for agriculture. Granby sandy loam, Brady sandy loam, and Maumee loam comprise this group. These soils are used for general farm crops where cleared and drained. Their value depends to a great extent on the types of soils with which they are associated.

(6) The alluvial soils are represented by Griffin loam and Genesee fine sandy loam, both of which are well suited to pasture and cultivated crops but occur in such small areas that many of them remain in forest.

(7) The organic soils include Carlisle muck, Houghton muck, Rifle peat, Greenwood peat, and Kerston muck. Where water levels are properly adjusted, the first three and the last are suitable for special crops, such as mint and truck crops, but Greenwood peat has very little agricultural value.

U. S. GOVERNMENT PRINTING OFFICE: 1941

Areas surveyed in Michigan shown by shading. Detailed surveys shown by northeast-southwest hatching; reconnaissance survey shown by northwest-southeast hatching.

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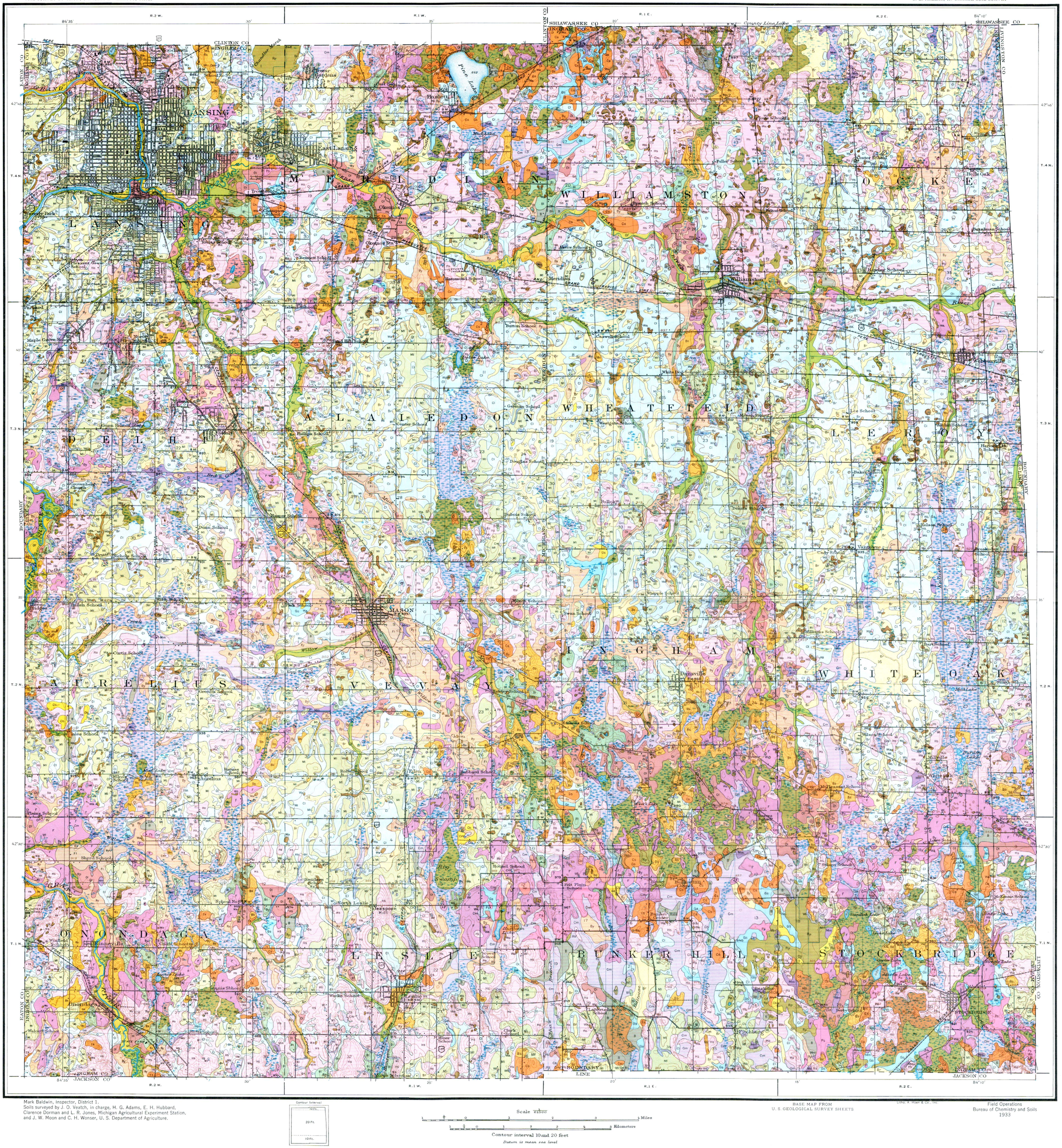
U. S. DEPARTMENT OF AGRICULTURE
BUREAU OF CHEMISTRY AND SOILS
HENRY G. KNIGHT, CHIEF
SOIL SURVEY DIVISION, CHARLES E. KELLOGG, CHIEF

SOIL MAP
INGHAM COUNTY
MICHIGAN

MICHIGAN AGRICULTURAL EXPERIMENT STATION
V. R. GARDNER, DIRECTOR
C. E. MILLAR, IN CHARGE SOIL SURVEY



LEGEND

- Bellefontaine loamy sand (Bl)
- Maumee loam (Mm)
- Bellefontaine sandy loam (Bs)
- Miami loam (Ml)
- Berrien loamy sand (B)
- Oshtemo loamy sand (Ol)
- Brady sandy loam (By)
- Ottawa loamy fine sand (Os)
- Brookston loam (Br)
- Plainfield loamy sand (Ps)
- Coloma loamy sand (Cs)
- Wallkill loam (Wa)
- Conover loam (Cl)
- Washtenaw loam (Wt)
- Carlisle sandy loam (F)
- Carlisle muck (Cm)
- Fox loam (Fl)
- Houghton muck (Hm)
- Genesee fine sandy loam (Gf)
- Kerston muck (Km)
- Granby sandy loam (Gs)
- Greenwood peat (Gp)
- Griffin loam (Gl)
- Rifle peat (Rp)
- Hillsdale sandy loam (Hs)

CONVENTIONAL SIGNS

CULTURE
(Printed in black)

- City or Village, Roads, Buildings, Wharves, Jetties, Breakwater, Levee, Lighthouse, Fort
- Secondary roads and Trails
- Railroads: Steam and Electric (Double track, Single track, Junction, Not in use)
- Bridges, Ferry
- R.R. crossings, Tunnel (R.R. above, R.R. below)
- Ford, Dam, Sawmill, Windmill
- Boundary lines (State, County, Civil township)
- School, Church, Creamery, Cemeteries
- Boundary lines (Reservation, Land grant, City or village)
- Triangulation station, Boundary monument, Oil or Gas wells
- U.S. Township and Section lines, Recovered corners
- Forest fire station, Airway beacon, Oil or Gas tanks
- Transmission line, Oil or Gas pipe line
- Mine or Quarry, Rock outcrop, Made land
- Soil boundaries, Stony, Gravelly and Cherty areas

RELIEF
(Printed in brown or black)

- Contours, Depression contours
- Prominent hills, Mountain peaks
- Sand, Wash, and Sand dunes
- Bluff, Escarpment, Mine dumps

DRAINAGE
(Printed in blue)

- Streams, Springs, Wells, Flowing wells
- Lakes, Ponds, Intermittent lakes
- Unsurveyed and Intermittent streams
- Water pipe lines, Canals, Ditches, Flumes
- Swamp, Salt marshes
- Submerged marsh, Tidal flats

The above signs are in current use on the soil maps. Variations from this usage appear in some maps of earlier dates.

Mark Baldwin, Inspector, District 1.
Soils surveyed by J. O. Veatch, in charge, H. G. Adams, E. H. Hubbard, Clarence Dorman and L. R. Jones, Michigan Agricultural Experiment Station, and J. W. Moon and C. H. Wonser, U. S. Department of Agriculture.

Contour Interval: 20 ft., 10 ft.

Scale 62500
1 mile, 0, 1, 2, 3 Miles
1 km, 0, 1, 2, 3, 4, 5 Kilometers
Contour interval 10 and 20 feet
Datum is mean sea level

BASE MAP FROM U. S. GEOLOGICAL SURVEY SHEETS

Litho. A. Hoen & Co., Inc.

Field Operations
Bureau of Chemistry and Soils
1933